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JOHNS HOPKINS UNIVERSITY CIRCULARS

Published with the approbation of the Board of Trustees

VOL. XX.—No. 152.] BALTIMORE, MAY–JUNE, 1901. [PRICE, 10 CENTS.

DEATH OF PROFESSOR HENRY A. ROWLAND.

The Johns Hopkins University of Baltimore announces in deep sorrow the death of Professor Henry A. Rowland, Ph. D., LL. D., Professor of Physics and Director of the Physical Laboratory in the University, which occurred at his home in Baltimore, April 16, 1901, in the fifty-third year of his age.

Professor Rowland was the son of Rev. H. A. Rowland, D. D., and was born at Honesdale, Pa., November 27, 1848. He was elected Professor in the Johns Hopkins University, April 3, 1876.

Among the Societies to which Professor Rowland had been elected were these:

FOREIGN.

The British Association for the Advancement of Science.
The Physical Society of London.
The Philosophical Society of Cambridge, England.
The Royal Society of London.
The Royal Society of Göttingen.
The Gioenian Academy of Natural Sciences, Catania, Sicily.
The French Physical Society.
The French Academy of Sciences.
The Literary and Philosophical Society of Manchester.
The Royal Lyncean Academy, Rome.
The Academy of Sciences, Stockholm.
The Italian Society of Spectroscopists.
The Royal Society of Edinburgh.
The Society of Arts, London.
The Royal Astronomical Society of England.
The Royal Society of Lombardy.
The Royal Physiographic Society of Lund.
The Royal Academy of Sciences, Berlin.

AMERICAN.

The American Philosophical Society, Philadelphia.
The American Academy of Arts and Sciences, Boston.
The National Academy of Arts and Sciences, Washington.
The American Physical Society,—its first President.

His academic degrees were these:

Civil Engineer (C. E.), Rensselaer Polytechnic Institute, 1870.
Doctor of Philosophy (Ph. D.), Johns Hopkins University, 1880.
Doctor of Laws (LL. D), Yale University, 1895.
Doctor of Laws (LL. D), Princeton University, 1896.

Among other distinctions may be named:

Officer of the Legion of Honor of France.
Rumford Medallist of the American Academy of Arts and Sciences.
Draper Medallist of the National Academy of Sciences.
Matteucci Medallist, (Italian).
Recipient of the prize of the Venetian Institute, for his work on the Mechanical Equivalent of Heat.

Delegate from the United States Government to the

International Congress of Electricians, Paris, 1881.
International Congress for the Determination of Electrical Units, Paris, 1882.
Electrical Congress, Philadelphia, 1884,—President.
International Chamber of Delegates for the Determination of Electrical Units, Chicago, 1893,—President.

The funeral was attended on April 18. The officers and students of the University and the pall-bearers met in the University, and after a brief address from the President accompanied the bier to St. Paul's Church where the burial service was read by Rev. Dr. Hodges, the Rector.

ADDRESS OF PRESIDENT GILMAN.

President Gilman's address to the members of the University was as follows:

A great man has fallen in the ranks—great in talents, great in achievements, great in renown. Not now need we recall the incidents of his life, nor estimate the characteristics of his impressive personality, nor enumerate his contributions to physical science. We are assembled in this academic hall as his friends, his pupils, his colleagues, about to follow his deserted body to the church, and there in silence to give thanks for such an example, or to utter, with his kindred, words of faith and hope, consecrated by the comfort they have given to the mourners of many climes and of many centuries. Before these last rites, we pause to think what sort of a man was this whom we so love and honor, whom we so lament, whose death, in one aspect, seems so premature; in another, crowned with the best that earth can give.

Our friend was born with a powerful mind, and the older he grew the more powerful it appeared to those who knew him intimately and to those most capable of understanding the problems and the methods which engaged his thoughts. Others may have eyes as keen and fingers as facile, but his vision and his dexterity were controlled by a brain of extraordinary fineness, versatility, and strength. Nobody could walk with him, hunt with him, sail with him, talk with him, work with him, without perceiving his firm grasp, his clear aim, his concentrated energy, his extraordinary powers. In early youth his mind was directed to the study of nature—not so much to plants and animals as to physical and chemical forces. This was the bent of his life. It is true that he was fond of music, classical music especially—Chopin's funeral march, for example,—and he loved good works of art—the Madonnas of Raphael, for example.

Yet he cared but little for literature, having showed, in his early days, a boyish animosity toward Greek and Latin which he never wholly overcame. Aristotle was no authority to him. But the mysterious forces of the physical world—gravitation, sound, light, heat, electricity and magnetism—were his constant study. The principles of mechanics were to him of fundamental importance, and mathematics was subservient to all his investigations. In this broad field he was a reader, a student, an experimenter, an inventor, a discoverer, a philosopher. He knew how to ask a difficult and far-reaching question, and he knew how to seek the answer.

Extraneous considerations were excluded when he saw the point of an inquiry, and on that point he concentrated all his powers. For example, when he began the brilliant series of experiments in spectrography, which made him peerless in this domain, he saw that the spectrum depended on the accuracy of the gratings, and the gratings on the dividing engine, and the dividing engine on the screw,—so he began the study of light by devising and making a screw, more exact than any screw that has ever been produced by the most accomplished makers of instruments of precision, and then he saw that photography must be improved before he could reveal to the eye of others the intricacy of the solar spectrum.

His intellectual apparatus was controlled by a powerful will. When he was determined upon a given course, no regard for consequences, no apprehension of perils or of difficulties, no dread of failure, proved a barrier. They heightened his zest. Fortunately his ends were noble and his proceedings wise, so that rarely, if ever, did failure disappoint him or weaken his self-confidence. He would have been a great soldier, a great explorer, a great lawyer.

But above his keen perceptions, his logic, his adaptation of means to ends, and his marvelous concentration, I must place another moral quality—one that appeals to every one of us, whether we understand his determination of the mechanical equivalent of heat, or the steps by which he arrived at the value of the ohm. This moral quality is the love of truth. Of course, he was true in all the ordinary relations of life. That is the beginning of truth, but not the end of it. He was also true in all his investigations, careful to eliminate errors, to avoid preconceptions, to shrink from hasty conclusions and inferences, to be critical of other investigations, to be accurate, exact, conscientious, to spare no pains, to shrink from no efforts, to conceal no difficulties, in order that the absolute facts might be established, so far as this can be done by limited humanity. To him science was another word for truth—not all the truth, but that amount of truth which the limited powers of man have discovered. He was a follower of Isaac Newton, picking up upon the seashore a few pebbles and discerning their lessons.

At the close of our first decennium, two speakers were brought forward to tell, respectively, what had been the aims of this University in providing for the study of science and letters. These speakers were Professor Gildersleeve and Professor Rowland. They had no preliminary conference, but each brought his discourse to a close by a return to the keynote—the keynote which had governed and should govern our personal behavior and the harmonies of our associated lives as members of the Johns Hopkins University.

Said the exponent of letters: "First and last, the scientific standard must be upheld for the university man, be he a student of letters, be he a physicist; and that standard is the absolute truth, the ultimate truth. 'Nothing imperfect is the measure of anything,' says the prince of idealists."

Said the man of science: "But for myself, I value in a scientific mind most of all that love of truth, that care in its pursuit, and that humility of mind which makes the possibility of error always present more than any other quality. This is the mind which has built up modern science to its present perfection, which has laid one stone upon the other with such care that it to-day offers to the world the most complete monument to human reason. This is the mind which is destined to govern the world in the future and to solve problems pertaining to politics and humanity as well as to inanimate nature.

"It is the only mind which appreciates the imperfections of the human reason and is thus careful to guard against them. It is the only mind that values the truth as it should be valued and ignores all personal feeling in its pursuit. And this is the mind the physical laboratory is built to cultivate."

These are words worthy to be recalled by the successive groups of students who come here for instruction and counsel as the years roll on. Let us sacredly cherish our inheritance.

In closing, let me call our departed brother, our dear colleague, our honored teacher, our ornament, our pride and our delight, by another nobler title. He was a Servant of the Lord. If one who leads a life of purity, fidelity, and integrity, and who consecrates, without self-seeking, his strength, his talents, his time, at home and at his laboratory, in health and in bodily infirmities, in youth and in maturity, to the interpretation of the laws by which the cosmos is governed, is a Servant of the Lord,—then reverently and truly we may say of our departed friend he was a Servant of the Lord, Maker of Heaven and Earth. Let me apply to him words of the Master, whom he was taught from childhood to revere. His "eye was single" and "his whole body was full of light."

MEETING OF THE FACULTY.

A meeting of the Faculty of the Johns Hopkins University was held in McCoy Hall on Saturday, April 27. President Gilman presided. Remarks were made by Professor Remsen, Professor Reid, Dr. Bliss (who read the memorial notice by Professor Ames), and by Professor Welch.

The following minute was adopted:—

We, the Faculty of the Johns Hopkins University, assembled to do honor to the memory of our late colleague, Professor Rowland, herewith record our appreciation of his genius and his services and our sorrow for his untimely death.

In losing Henry Augustus Rowland we have lost a great light, a great force, a great example. His fame abides and will ever be a precious possession of the University, inseparably connected as it is with the foundation and the growth of the institution, but in the withdrawal of a unique personality and the sudden close of a career of high performance and, if possible, still higher promise, our collective life has suffered a loss which is as incalculable as genius itself. Rowland's eminence as a physicist is indisputable. There is no danger of an overestimate. The only danger is that we who stood so near him have not taken the full measure of the man as he will appear to after times. Of his manner of work those only who were closely associated with him have a right to speak, and yet even they could only divine the swift processes of his intellect, his marvellous intuitions, and admire with the rest of the world his penetrating vision, his unfailing directness in the quest of truth. In every problem he sought the ultimate principle, and the moral lesson of his scientific life is not less impressive to those who were not engaged in his special line of work than it is to those who followed him as pupils follow a master, as fellow workers follow a gifted leader. This directness, this honesty characterized him throughout. He was a man of one piece. There was no affectation in his manner of living, no sham interest in that which lay outside of his field of work or his personal sympathy. He felt the responsibility of his gifts, the importance of his message, and those who came within the range of his influence owe as much to his singleness of purpose as to the illumination of his intellect.

Yet in paying our tribute to Rowland's high intellectual and moral endowments, we must not overlook the human side of this rare man. In all the intimate relations of life, his fidelity, his devotion and his generosity matched his exalted scientific standard, and those who called him friend, and those who shared the hours of relaxation which lessened the strain of his intense work, will carry with them to the end an affectionate remembrance of the great physicist whose work for the University, for the country, and for the world the annals of scientific research and invention will not suffer to be forgotten.

Resolved, That this minute be transmitted to the Trustees with the request that it form a part of their permanent record, and that a copy be communicated by them to Mrs. Rowland and to the family of our late colleague.

ACTION OF THE TRUSTEES.

May 6, 1901.

The Trustees of the Johns Hopkins University having received the foregoing minute expressed their entire concurrence in this tribute of regard for one of the most brilliant men connected with this University since its foundation, and directed that the minute be inscribed upon their records and that a copy be sent to Mrs. Rowland.

MEMORIAL NOTICES OF PROFESSOR ROWLAND.

[Reprinted from *Science*, New York, May 3, 1901.]

In the death of Professor Rowland, at the age of fifty-three, in the fulness of his activity and powers, the world has lost one of its foremost men of genius; America, its greatest scientist; the Johns Hopkins University, the teacher and investigator who has brought it most renown.

Henry Augustus Rowland was born at Honesdale, Pennsylvania, November 27, 1848; he entered the Rensselaer Polytechnic Institute, Troy, and received the degree of C. E. in 1870. After a brief experience in practical engineering on a railroad he accepted the position of teacher of science in Wooster College, where he taught physics, zoology and geology for the year 1871–2. He was then called to the Rensselaer Institute as instructor, and was soon promoted to assistant professor. He remained at Troy until he accepted a position at Johns Hopkins University in 1875. The attention of President Gilman of Johns Hopkins University was directed to Rowland by Professor Michie of West Point; and the first meeting of the two took place at the Academy on the Hudson. Before assuming the duties of his new office, at the suggestion of President Gilman, he spent a year in Europe purchasing apparatus for his laboratory, becoming acquainted with the prominent scientists of England and the Continent, and making a prolonged stay in Berlin in order to carry out in Helmholtz's laboratory an investigation which he had long contemplated. He returned to America in 1876, was made professor of physics at Johns Hopkins, and at once began his work. His influence was immediately felt not alone in the University, but throughout the whole country; and students came from both North and South to receive inspiration and guidance. As research after research, discovery after discovery, was made, honors came from both home and abroad; his reputation and renown increased until in the whole country there was no one whose influence in all fields of scientific study or application was so great. It was in Baltimore that nearly all his great work was done, and it was here that he died on the 16th of April.

Professor Rowland was honored by being elected a member of many scientific bodies. He was Honorary Member of the Royal Society of London; Honorary Member of the Royal Society of Edinburgh; Honorary Member of the Royal Academy of Sciences, Berlin; Corresponding Member of the Royal Society of Göttingen; Corresponding Member of the Academy of Sciences in Paris; Honorary member of the Cambridge Philosophical Society; Honorary Member of the Physical Society of London; Foreign Member of the Royal Swedish Academy of Stockholm; Associate Fellow of the American Academy of Arts and Sciences; Member of the National Academy of Sciences, and a member of nine other learned societies.

He was awarded the Rumford Medal by the American Academy in 1884, the Matteucci Medal in 1897, and received medals at the Exhibitions of Chicago and Paris. He received the honorary degrees of Ph. D. from Johns Hopkins in 1880 and of LL. D. from Yale in 1895 and Princeton in 1896. He was made an officer of the Legion of Honor in 1896.

Even as a young man, Rowland was occupied continually with problems and questions pertaining to chemical and physical science; he had his own laboratory and workshop in which he performed experiments and constructed apparatus. He read the works of Faraday and others and made their subject-matter thoroughly his own. His note-books kept when he was still a youth are full of most remarkable conjectures as to the undiscovered truths of nature, of proposed experiments, of most discriminating and accurate observations, and of many interesting theoretical discussions. It is to be earnestly hoped that the contents of these books will some day be published.

It is hardly necessary to give more than a summary of his most important researches. While at Troy he made those investigations on magnetic induction, permeability and distribution, which at once attracted the attention of Clerk-Maxwell. In Berlin he carried out his experiments on electric convection, which proved that an electrostatic charge carried at a high rate of speed has the same magnetic action as an electric current. (The results of this experiment have recently been called in question; but a repetition of the work during the past winter has confirmed them.) His first important piece of work in Baltimore was the determination of the mechanical equivalent of heat, which necessitated more careful thermometric and calorimetric methods than had ever been used before. He then became interested in questions dealing with electricity and, realizing the importance of accuracy in the measurement of electrical quantities, made a most careful determination of the ohm. This work was repeated and extended later, at the request of the United States Government.

The great problem of the connection between ether and matter was always before him, and in the desire of adding something to our knowledge he devised many experiments which were carried out by his students under his immediate direction; of these the most important were the one performed by Professor Hall, which led to the discovery of the "Hall effect," and those recently performed by Dr. Gilbert, which have led to purely negative results. Becoming interested in the study of spectrum analysis, largely through the influence of his colleague Professor Hastings, he realized the importance of securing as perfect gratings as possible. So he constructed a dividing engine for the ruling of gratings, the essential parts of which were a screw of nearly perfect uniformity of pitch and a most ingenious device for the correction of periodic errors. With this machine many gratings were ruled on both glass and speculum metal, the surfaces being plane. But the idea occurred to him to investigate the action of a grating ruled on a spherical concave surface; he discussed the question mathematically and thus discovered the great advantages of such "concave gratings," and proceeded at once to rule them. (It should be noted that all the gratings, both plane and concave, which have been ruled under Professor Rowland's direction and are now in use in all the physical laboratories in the world, have been sold at such prices as simply paid the wages of the laboratory mechanician who supervised their construction.) With these gratings the study of the solar spectrum was begun; and in order to supplement eye-observations, he made a careful study of photographic methods, and prepared his own photographic plates. Having mapped the whole solar spectrum from the extreme red to the limits in the ultra violet, he had enlarged maps prepared and offered to the world. Then he undertook the systematic study of the arc-spectra of all the elements, so far as possible; and the final results of this long research are now nearly ready for publication. Within recent years his attention had been called to the theory of alternating currents and to their application for practical purposes. He devised a system of multiplex telegraphy depending upon synchronous motors, which received a grand medal at the Paris Exposition of 1900.

These are but the most important of Rowland's contributions to science; a complete list would be even more striking. Far more important, however, than the results of the investigations themselves, is the spirit, the aim of the man as made manifest in them. His great purpose was to discover not simply the truth in nature, but the deeply hidden truth. Questions pertaining to the *fundamental* properties of electricity, magnetism, ether and matter were always in his mind; the exact measurement of spectrum lines was interesting to him only in so far as the results might lead to accurate knowledge of molecular constitution or of solar and stellar phenomena; all instruments or methods perfected by him were those which could be used to measure the *great* constants of nature.

To appreciate properly Rowland's greatness as an investigator one must have worked with him. He enjoyed to the utmost the rare gifts of intuitive knowledge and of self-confidence. His energy, his manual dexterity, his ingenuity, his keenness in perceiving and avoiding experimental errors, his skill in devising apparatus, were always evident. No scientist of this generation has had greater power than he of using his imagination under the restraints and guidance of scientific knowledge.

As the director of a great physical laboratory, Rowland was in some ways unique. His enthusiasm and the inspiration of his example were always of the greatest help; his suggestions were invaluable; but his critical powers, his deep insight into any physical problem, his searching questions were the qualities of untold benefit. He rarely delivered a lecture without calling attention to some subject which needed experimental study; he was never present at a meeting where scientific papers were read or discussed without pointing out some error or possible improvement in the method of experimenting. He was rarely on intimate terms with his students; but no one came near him without recognizing his sweetness of character, his entire freedom from petty faults, his absolute unswerving devotion to the pursuit of truth.

J. S. AMES.

JOHNS HOPKINS UNIVERSITY.

[Reprinted from *Nature*, London, May 2, 1901.]

Henry Augustus Rowland was born in 1848. He was educated as an engineer, and graduated at the Rensselaer Polytechnic at Troy, New York, in 1870. After one year's experience as a railway engineer on the Western New York Line, and a second spent as instructor in natural science at Wooster, Ohio, he returned to his college to share in its teaching, becoming an assistant professor in 1874. Two years later, in 1876, after spending a year under Helmholtz in Berlin he took office as the first professor of physics at the newly founded Johns Hopkins University. Baltimore remained his home until his death, on April 16, at the early age of fifty-three years.

His work at Berlin on the magnetic effects due to a moving body when carrying an electric charge brought him at once into fame. The result was published by von Helmholtz in 1876, and is thus described by Maxwell in a metrical letter to Tait, written in June 1877. Tait had inquired, also in verse, as to the electric effects to be expected if a disc of ebonite carrying a charge were made to rotate in its own plane, and Maxwell writes:

> The mounted disk of ebonite
> Has whirled before nor whirled in vain,
> Rowland of Troy, that doughty knight,
> Convection currents did obtain,
> In such a disk, of power to wheedle
> From its loved north the subtle needle.

Rowland showed by the direct effects produced on a magnetic needle that a charged body in motion gave rise to a magnetic field just as though it were a current whose strength depended on the product of the charge and the velocity.

This result is of fundamental importance to electrical theory; it was confirmed by Rowland and Hutchinson in 1889, and has been generally accepted as an established fact. Within the last few months, however, Cremieu has published an account of a repetition of Rowland's experiment which has led him to a negative result; the question just at the present moment appears to need further investigation.

Rowland's appointment at Baltimore was rapidly followed by a series of brilliant researches, each of the first importance. His determination of the unit of resistance came first. This was published in 1878. The original B.A. units were constructed by the Electrical Standards Committee in 1863–4 to represent 10^9 C.G.S. units of resistance; according to Kohlrausch's results in 1870 they were 2 per cent. too high, while according to Lorentz (1873) they were 2 per cent. too low. Rowland's paper contains an able criticism of the old experiments and a detailed account of his own which led him to the number $\cdot 9912 \times 10^9$ C.G.S. units as the value of the B.A. units. Further experiments in 1887 reduced this to $\cdot 9864 \times 10^9$. The value now generally accepted is $\cdot 98653 \times 10^9$. Rowland himself employed a modification of Kirchoff's original method, in which the induction current in a secondary circuit produced by reversing a measured primary current in a neighbouring circuit is observed.

In 1879 Rowland presented to the American Academy of Arts and Sciences his paper on the mechanical equivalent of heat, with subsidiary experiments on the variation of the mercurial from the air thermometer, and on the variation of the specific heat of water. To attempt to give any account of the contents of this classic work would occupy too much space. To appreciate its value and to realize the skill and the ingenuity of its author it must be studied itself. More is known now about exact thermometry and the precautions necessary in using a mercury thermometer, and so it has come about that some corrections are necessary in Rowland's work, specially in that part of it which deals with the relation between the scales of the mercury and the air thermometer. These corrections were made at the Johns Hopkins University by Messrs. Day and Wardner and Mallory; but this fact detracts nothing from the importance of his investigation, and among the many determinations of the value of Joule's equivalent, Rowland's will always remain in the front rank.

Passing over, for the present, much work of great value, among which we may note his investigations into the magnetic permeability of various substances, published in the *Philosophical Magazine* for 1873 and 1874, and his theory of Hall's effect, we come next to the year 1882, when Rowland gave to the Physical Society of London an account of his concave grating. This is published in the *Philosophical Magazine* for September, 1883.

The results of this discovery are well known. A new weapon was placed in the hands of spectroscopists; it became possible to photograph spectra directly without the use of prisms or lenses, and with a greatly increased dispersion and resolving power; the beautiful maps issued at a later date by Rowland himself, and by Higgs of Liverpool, are striking evidences of the value of the grating; the additions to our knowledge arising from this one discovery are already enormous; much has been achieved which, without it, would have been impossible.

Rowland's own researches with his grating are summed up in his map of the solar spectrum and his table of the wave-lengths of the elements published in 1893 (*Phil. Mag.*, July, 1893, reprinted from *Astronomy-* and *Astro-Physics.*)

Of late years he gave much time and attention to a system of multiple telegraphy; this was shown working at the Paris Exhibition last year.

Enough has been written, perhaps, to indicate the debt physical science owes to Rowland; it is said he never received any regular instruction in physics; he was an engineer, and to this, in great measure, his success is due. The accuracy of his work on the ohm depends on the care he took to construct his induction coils so that their dimensions could be accurately measured; he dealt with the determination of the mechanical equivalent as an engineering problem; he employed a large mass of water and used steam power to rotate his paddle at a speed sufficient to make the resulting rise in temperature one that could be measured with accuracy.

The theory of the concave grating was his, but its success was due to the fact that Rowland had made an almost perfect screw; the method he employed in this is given in his article "Screw," in the "Encyclopædia Brittanica."

He lived for his work, but in his earlier days he was passionately fond of riding. Some years after the publication of the paper on the mechanical equivalent he was awarded a prize for it by one of the Italian Academies; about the same time he won a steeplechase, riding his own horse; he hardly knew which event gave him the greater pleasure. Another time, passing through England on his way home from the Continent, he had three days to spare. One of these was passed at Cambridge discussing electrical measurements, the other two were spent in a hurried visit to Exmoor to get a run with the staghounds. Twenty years ago he was a frequent visitor to England, and attended several of the meetings of the British Association; recently his visits were much less frequent. His friends here were aware that he was not well; some few weeks ago it was known that he had had a serious illness, but the news then was that he was better and on the road to recovery; however, an operation proved necessary, and he never recovered from its effects.

Thus within the last few months physical science is the poorer by the deaths of two of the most brilliant of the followers of Maxwell—Fitzgerald and Rowland; two who were foremost among those who have given to the theory of Faraday and Maxwell the right to claim the position of the theory of the electro-magnetic field.

R. T. G.

[Reprinted from *The Baltimore News*, April 16, 1901.]

The news of the sudden death of Professor Rowland will come as a most painful shock to his friends, to the friends of the Johns Hopkins University, and to all who are acquainted with his splendid services to science. His contributions to physics have made his name honored throughout the world, and he has been one of the Americans to whom his countrymen could point as most notably representing their country in the domain of scientific research. Identified as he was from the beginning with the work of the Johns Hopkins University, and carried away so suddenly while in the prime of his power, it is impossible to realize that he is no longer to be a familiar figure in the intellectual life of this city.

Professor Rowland was one of the most brilliant of that company of professors who were brought together at the opening of the Johns Hopkins University as leaders in the various departments of instruction. He was then but 28 years old, but had already won distinction as an original and acute student of important problems in the department of physics. In early life he had shown the rare qualities by which he was subsequently distinguished. His note books show the important problems that he investigated and the exact methods that he followed in the prosecution of his researches.

Having failed to find in the Sheffield School at New Haven, the opportunities for study that he sought, he went to Troy, and became a student of the Rensselaer Polytechnic Institute, where he received the degree of civil engineer. He was presently made an instructor in that institution, and without good facilities for investigation, without good apparatus and without assistance—one may also say without guidance—he investigated certain electrical phenomena. The papers embodying the results of these researches were at once accepted by the London, Dublin and Edinburgh Philosophical Magazine, one of the leading journals in the world in physical science. These papers were so profound and so suggestive that Mr. Rowland was at once recognized as a scientific thinker of rare ability.

The Trustees of the Johns Hopkins University were then looking for leaders. The name of Professor Rowland was brought to their attention by Professor Michie, of West Point, who knew him personally, and who was also a man of distinction in the subject for which Professor Rowland showed such proclivities. When they heard his story the Trustees invited him to join the staff of the University, and gave him an opportunity to go abroad for a year in order that he might work in some foreign laboratory, and might come into relations with scientific leaders in England, France, and Germany. He spent the winter of 1875–76 in Berlin, as a student in the laboratory of Von Helmholtz, and came back to Baltimore in time to begin the work with which his name has since been identified. By a series of fundamental investigations carried on during his residence here, he made important contributions to the science of physics, and won the highest distinction abroad and at home. The leading academies of Europe conferred upon him the high honor of foreign membership, and he was naturally the recipient of abundant distinction from the universities and scientific associations of his own country.

His industry, his originality, his power of concentration, his love of truth, were among his most conspicuous intellectual qualities, while his integrity, fidelity and unselfishness were obvious in all his relations to his fellow-men. His death will be profoundly lamented not only in the scene of his recent activities, but wherever there is interest in the advancement of science.

[Reprinted from *The Sun*, New York, April 20, 1901.]

The country lost one of its great men in Professor Rowland, who died in Baltimore on Tuesday. For the past quarter of a century he was professor of physics at the Johns Hopkins University, and his profound mathematical and inventive genius has made his laboratory famous all over the world. With Helmholtz, Stokes, Clerk-Maxwell, Lord Rayleigh, Hertz and a few others, he belonged to the very highest type of discoverers; and he has left a name among his fellow-men of science that is, in very truth, immortal. So long as spectroscopy is a science, so long will his invention of the concave diffraction grating be remembered, so long will the marvellously delicate pieces of apparatus by which these gratings are ruled be praised. It is, indeed, a literal truth that every diffraction grating now in use by scientific men all over the world was made either by Dr. Lewis Rutherfurd, of New York, or by Rowland's processes. It is not too much to say that spectroscopy has been revolutionized by his inventions. His discoveries in electricity and magnetism were of the first order—the discovery that electric convection produced magnetic action being, perhaps, the most brilliant.

In the domain of heat, his researches were equally important. It is to Rowland that we owe the exact determination of the value of the mechanical equivalent of heat—a fundamental constant. The accepted values of electrical standards are in very many cases his also. There is no part of physics in which he was not distinguished. Although all but unknown to his fellow-countrymen in general, he was covered with honors by those who could appreciate his brilliant genius. Degrees from a dozen universities in America and Europe were bestowed on him *honoris causa.* Scientific societies of all countries gave him their medals. He was a member of our National Academy of Sciences, of the Royal Society of London, of the Institute of France, of the Academies of Berlin, Göttingen, Rome, Genoa, Stockholm, and a score of others. He was made chevalier of the Legion of Honor in 1881, and officer in 1896.

Hundreds of pupils have passed through his laboratory at the Johns Hopkins University, and not one of them has failed to recognize the master. Very many of them are now filling professional chairs in our colleges. He was a model teacher for the gifted, but wasted no time on the commonplace pupil. For the commonplace, for the thing without distinction, he had little tolerance. It is precisely for this reason that his influence as a teacher was so valuable during the past generation.

Johns Hopkins University with its faculty of 1876—Rowland, Gildersleeve, Sylvester, Remsen, Martin—stood boldly forth for the principle of distinction, and has maintained it manfully. In that little group of able men Rowland held a high place from the very first, though he was but 28 years of age at the time of his appointment.

In all respects he was a model man of science. In every scientific circle his name is honored. He cared for no wider recognition, but it is a duty for us, his fellow-citizens, to lay this tribute of appreciation and gratitude on his grave. May the coming generations of American men of science follow in his footsteps!

CONTRIBUTIONS FROM THE GEOLOGICAL DEPARTMENT.

Edited by Professor WILLIAM BULLOCK CLARK.

THE PLEISTOCENE PROBLEM OF THE NORTH ATLANTIC COASTAL PLAIN.

By GEORGE BURBANK SHATTUCK.

In that portion of the Atlantic Coastal Plain which lies between the Raritan and Potomac rivers there is a mantle of loam, sand and gravel covering most of the earlier deposits of the lowland and lapping well up on the Piedmont Plateau. This veneer of unconsolidated deposits has long attracted the attention of explorers and various opinions regarding its relations and structure have been entertained. The attention of the earlier geologists was largely taken up in unravelling the history of the more attractive crystalline and fossil-bearing rocks, and in problems connected most intimately with glaciation, and it was not until Mr. W J McGee, formerly of the U. S. Geological Survey, undertook the study of these surficial deposits that their true relations began to appear. The conclusions on this subject which Mr. McGee has published from time to time during a period of fourteen years may be briefly summarized as follows.

Views of Mr. W J McGee.

The Lafayette, which is a series of orange-colored loams, sands and gravels, extends up, according to Mr. McGee, from the south and occupies the divides and higher portions of the Coastal Plain of Virginia as far north as Fredericksburg. Distinct from these deposits both in origin and age, is another series of loams, sands and gravels designated by him as the Columbia formation, which fill the valleys of the present streams and mantle the divides between them. This formation is divisible into two phases, fluvial and inter-fluvial. The fluvial phase is composed of deltas which were deposited under water, by those streams in whose valleys they now lie, when the land stood lower than it does to-day. The inter-fluvial phase is found on the divides and is a littoral deposit made by the waves which beat against the coast at the same time the rivers were building their deltas. The two phases are therefore contemporaneous and grade over into one another. The fluvial phase exhibits a distinct bi-partite division. The upper member consists of a brick-clay and loam, and the lower member is composed of sand, gravel and huge boulders. The material as a whole, is coarser near the mouths of the gorges where the rivers leave the Piedmont Plateau to pass into the Coastal Plain than it is in the more remote portions of the delta. The inter-fluvial phase possesses no such regularity of bedding, but is indiscriminately composed of clay, sand and gravel largely of local origin. These delta deposits may be identified in all the principal rivers of the Middle Atlantic slope and are particularly well developed in the valleys of the Potomac, Susquehanna and Delaware. Due to the presence of these huge boulders, which were evidently ice-borne and indicate a climate much colder than exists to-day in the same region, as well as to the fact that the Columbia, when traced northward, is found to pass under the terminal moraine, it was concluded that it was Quarternary in age and belonged to the earlier glacial advance. These beds, since their deposition, have been raised and tilted so that they now lie higher in the regions to the north than they do further south. Their present elevation was found to be about 500 feet on the upper Susquehanna and 245 feet at its mouth; 400 feet on the upper Delaware; 145 feet on the Potomac; 125 feet on the Rappahannock; 100 feet on the James and 75 feet on the Roanoke.

Mr. McGee also noted certain well-defined terraces which were distributed over the entire region, and spoke of them as follows:[1]

"There is a practically continuous series of terraces and beach marks along the fall line from the Roanoke to the terminal moraine—a series of shore lines as distinctive and unmistakable as those circumscribing the valleys of the extinct lakes of the Great Basin, of India, of northern Arabia, or of the partially ice-bound basins of Minnesota, Michigan, Ohio and New York, though they are generally more profoundly modified by erosion, and are frequently concealed by forests. These shore lines embody an easily interpreted record of geologic vicissitude which coincides in every detail with that of the Columbia deposits. They are sometimes carved out of the sub-terrane but are generally built of the loam, sand and gravel of which the Columbia formation consists, and are evidently coeval therewith. Now it is evident that these terraces are water fashioned; but they are not fluvial. . . . . The forces concerned in the formation of the Middle Atlantic slope terraces acted horizontally over great distances and with uniform energy for a considerable period, filling depressions, softening contours, and obliterating relief, yet so gently that essential homogeneity of deposit in the horizontal direction and essential uniformity in surface prevails for miles. Only the undulatory and horizontally acting force of waves appears competent to produce so great expanses of uniform surface and constant structure as are exhibited in this region."

A summary of Mr. McGee's views regarding the various land movements as expressed by the present state of the Lafayette and Columbia deposits is as follows:

Post-Chesapeake, - - - - - - - -	elevation and erosion.
Lafayette (Pliocene?), - - - - - -	depression and deposition.
Post-Lafayette, - - - - - - - -	elevation and erosion of at least 500 feet; present topography defined.
Early Columbia (Pleistocene), - -	depression of about 200 feet and deposition.
Post-Early Columbia, - - - - - -	elevation and erosion.
Later Columbia, - - - - - - -	depression of about 100 feet and deposition.
Post-Later Columbia, - - - - - -	elevation and erosion.
Present, - - - - - - - - - - -	depression and deposition.

At the New York meeting of the American Association for the Advancement of Science during the summer of 1900, Mr. McGee took occasion to refer to certain relations of the gravels as developed in the vicinity of Washington. After reviewing briefly the various deposits which occur in that region, he is reported by Mr. J. A. Holmes as making the following statement.[2]

"In a few localities, especially in the deep cutting in the 200-foot terrace at the end of Sixteenth Street, deposits have been observed which fail to fit into this series. This cutting reveals, unconformably beneath the Earlier Columbia and unconformably above the Potomac, a heavy deposit of loam and gravel of a structure, composition, texture and material simulating the Earlier Columbia formation in its normal aspect, save that the materials are more extensively disintegrated and decomposed. The resemblance of the deposit to the Earlier Columbia is such that it might readily be classed with that formation if found isolated; but in the Sixteenth Street exposure the two deposits are juxtaposed and separated by a well-defined unconformity—i. e., the stratigraphy shows that the deposit in question is materially older than the Earlier Columbia. On comparing the deposit with the Lafayette, as displayed in the nearest exposures of that formation on the west, north and east, it is found to be so different in materials and structure as to demand separation on lithologic grounds; moreover, the deposit is confined to a depression, or amphitheatre, which did not exist at the time of Lafayette deposition, but was produced during the period of rapid degradation accompanying the post-Lafayette uplift; so that it must be discriminated from the Lafayette on the basis of homogeny as well as on that of lithology. The interpretation of the deposit is simple: it is evidently a record of an oscillation during the post-Lafayette and pre-Columbia time, which was not of such amplitude and length as to inscribe itself deeply in the local series of formations and land-forms. On seeking to correlate the deposit with other elements in the coastal-plain series, difficulty is encountered; no corresponding deposits are known either southward or eastward in Virginia and Maryland; the nearest known deposits of corresponding character and position are a part of those found in southern New Jersey, and first grouped by Salisbury under the designation Pensauken, but afterward divided."

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[1] *Am. Jour. Sci.*: Vol. 35; 1888, pp. 387–388.

[2] *Science*, n. s., Vol. xii, 1900; pp. 990–991.

Pressure of other duties prevented Mr. McGee from continuing the investigations which he had so happily commenced, and Mr. N. H. Darton, of the U. S. Geological Survey, took up and carried forward the work where Mr. McGee left it.

Views of Mr. N. H. Darton.

According to Mr. Darton, the Lafayette formation does not end at Fredericksburg, but in disconnected areas, crosses Maryland, Delaware and Pennsylvania, into New Jersey. In this connection he said:[1] "The northern termination of the deposits was supposed to be near Potomac creek, a few miles north of Fredericksburg; but I have found that while there is a break in its continuity in the region east of the Potomac river, it soon begins again and thence continues northward probably through Maryland, and in attenuated scattered outcrops, through Delaware and into Pennsylvania and New Jersey. It is displayed in the high terraces about Washington, and it caps nearly all the higher terrace levels of the "western shore" of Maryland northward to the latitude of Baltimore. Still farther northward it is confined to outliers on the divides along the western margin of the coastal-plain region; but at the head of Chesapeake bay it extends farther eastward and, in the high Elk ridge, caps the Cretaceous and Potomac formations over a considerable area."

The Lafayette was also described as continuing down the peninsulas of the Coastal Plain.[2] In this connection he said: "I have found that the formation extends eastward down the coastal plain peninsulas nearly to Chesapeake bay. These peninsulas consist of remnants of an elevated plain, occupied by a sheet of Lafayette formation, and originally continuous over the entire coastal plain. This plain is inclined gently eastward, its latitude decreasing from 500 feet in the Piedmont region, to from 60 to 80 feet in the vicinity of Chesapeake bay, where it is terminated by an abrupt descent to the low Pleistocene terrace bordering the bay to a width of several miles."

The Columbia of Mr. McGee is found by Mr. Darton to be divisible into an earlier and a later member, which are developed in well-defined terraces, the former lying normally above the latter. The land surfaces upon which the Lafayette and Columbia terraces were deposited has been raised and tilted at various times in such a manner that only in that part of the Coastal Plain which lies near the Piedmont is the normal sequence present, while in that portion bordering on Chesapeake Bay the normal sequence is reversed. This state of things was brought about in the following way: At the close of the Lafayette deposition, the surface on which that formation rested was raised and tilted so as to slope eastward toward the sea, and after suffering considerable erosion, it was depressed in such a manner that its eastern portion was submerged while its western margin bordering the Piedmont Plateau remained above water. In the estuaries thus formed and along the coast, the earlier Columbia formation was then deposited. This formation, therefore, built up a terrace below that of the Lafayette in the heads of the estuaries near the Piedmont, but covered up the Lafayette surface where it was submerged to the east. While the deposition of the earlier Columbia was still in progress, the Coastal Plain again tilted so as to bring that portion of it lying to the northeast and against the Piedmont above water, while the southeastern portion was still further depressed. The later Columbia was in its turn deposited in the estuaries beneath the earlier Columbia where the latter had been elevated, and above it where it had been depressed. Consequently the three formations near the Piedmont were developed in separate terraces lying one above the other, the Lafayette at the top, with the earlier Columbia in the middle and the later Columbia at the bottom, while in the eastern submerged portion the formations were not developed in terraces, but in a continual series, with an erosion break between the Lafayette and the earlier Columbia. In this region the sequence ran, beginning at the top, later Columbia, earlier Columbia, and Lafayette.

Mr. Darton has published a number of geologic maps from time to time in which these relations are depicted. In an early map of the Washington region, he included only two formations of gravel, the Lafayette and Columbia, but in a later and revised edition, which is now in the press, and which he has been kind enough to show me, three formations of gravel are portrayed, the earlier and later Columbia and Lafayette, developed in distinct terraces, lying one above the other as described. The Nomini and Fredericksburg folios of the Geologic Atlas of the United States convey his ideas regarding the sequence of gravel in portions of southern Maryland and eastern Virginia. In these publications he distinguishes two gravels lying in distinct terraces, the Lafayette above, covering the divides, and the Columbia beneath, occupying the valleys.

Views of Professor R. D. Salisbury.

Professor R. D. Salisbury commenced his work on the detailed survey of the Pleistocene deposits of the Coastal Plain of New

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[1] *Bull. Geol. Soc. Amer.*, Vol. ii, 1891, p. 445.

[2] *Amer. Geol.*, Vol. ix, 1891, p. 181.

Jersey in the summer of 1891. In his first report[1] he mentions a number of peculiar deposits bearing glaciated boulders which he states were somewhat like till in character. The following is quoted from the Report of the State Geologist of New Jersey for 1891, page 107:

"Drift, closely resembling till and containing striated rock material, occurs on the west side of the Delaware, near Fallsington, three or four miles southwest of Trenton . . . the writer found similar deposits at Bridgeport, Pa., opposite Norristown, still further south. . . . Glaciated bowlderets were here taken from clay of such character that, were the locality known to have been covered by ice, its reference to till would be fully warranted. Bridgeport is about fifty miles south of the terminal moraine.

"It is not intended to convey the impression that every region where glaciated stone may be found was necessarily once covered by glacier ice. The possibility of transportation of glaciated material beyond the edge of the ice by water, is distinctly recognized. But it is not believed that water alone, or water-bearing glacially-derived bergs could produce all the results which are here recorded. Neither the structure of the extra-morainic drift, nor its physical make-up, nor its geographic or topographic distribution, is consistent with such an hypothesis.

"At several points in New Jersey south of all the localities thus far mentioned within the State, there are topographic features which are easy of explanation if ice once extended to the region where they occur, but which seem to be very difficult of explanation on any other hypothesis. The features here referred to characterize the region from Washington, Middlesex County, southwest to Fresh Ponds and beyond, and also the region east of Trenton, from White Horse to Hamilton Square. The topography in these regions is very much like that of a subdued terminal moraine."

In his report for 1892, Professor Salisbury discusses at some length the character and origin of the Trenton gravel; he shows very plainly that it was a valley train deposited by the Delaware river from materials washed from the glaciated regions, and states that it was deposited "during that stage of glaciation when the ice edge stood near Belvidere." He then discusses the Yellow Gravel formation of Professor Cook and shows that it recorded a most complex history. His conclusions may be summarized as follows:

First. "The time of deposition of the original yellow gravel." This covers the period when the country was sufficiently low to allow the gravel to accumulate on hills which are now nearly 400 feet high, at least, south of Matawan. Age pre-Pleistocene.

Second. "An epoch of elevation and extensive erosion." This covers a period when the yellow gravel was raised and the land surface greatly eroded.

Third. "An epoch of depression." This embraces a period when central and southern New Jersey was 150 feet lower than now. This depression is correlated with the first glacial epoch and is also tentatively correlated with the Columbia.

Fourth. "An epoch of elevation and erosion." During this time the land was raised to a greater height than before and the streams cut deeper valleys than during the early epoch of elevation.

Fifth. "An epoch of slight depression." Correlated tentatively with the last glacial epoch and also was the period when communication was established between Raritan Bay and Trenton.

Sixth. "Subsequent elevation." An elevation of 40 to 60 feet followed by the present subsidence.

Professor Salisbury in his report for 1893 divides the yellow gravel for the first time into four well-defined periods: the first and the oldest he calls the Beacon Hill; the second, Pensauken; the third, Jamesburg; and the fourth is left unnamed, but later, in a subsequent publication, is called Cape May.

The Beacon Hill formation appears to be Miocene, and therefore, will not enter further into our discussion of the gravels.

According to Professor Salisbury, the Pensauken was deposited in valleys cut out during the post-Beacon Hill elevation. It is considered to be an aqueous formation, and its distribution indicates that the land was submerged 200 feet during its deposition. One of the chief diagnostic features of this formation is the presence of decomposed boulders of gneissic and granitic material found imbedded in its mass. The formation ranges in elevation from 200 feet at Perrineville to 80–90 feet south of Palmyra. The elevation is also regarded as being more in the region of Beacon Hill than elsewhere. At South Amboy its presence is indicated at an elevation of 147 feet.

The name of the formation is derived from Pensauken Creek but the statement is made that the formation is most characteristic near South Amboy, and that the latter locality would have been chosen to typify the formation were it not for its association with the plastic clays.

In the report for 1894 Professor Salisbury points out that a submerged trough formerly existed in central New Jersey extending from Raritan Bay to Delaware Bay, allowing a communication between these two bodies of water and separating southeastern New Jersey from the mainland as an island. In this trough were deposited the Pensauken and Jamesburg formations and the Trenton gravel. Various elevations of the Pensauken are also mentioned in this report. The most noted differences in elevations are the following: at Fish House, the elevation of the Pensauken is stated as 15 feet where it lies immediately under the Fish House clays, the latter being regarded here as post-Pensauken. Nine miles southeast of Fish House, the base of the Pensauken is at an latitude of 150 feet, thus making a rise of 15 feet per mile. Professor Salisbury also reaffirmed the deformation of the Pensauken surface since its deposition. The age of the Pensauken is ascribed to the Lafayette in the following terms: "There can no longer be any doubt that the Pensauken is the equivalent of the Lafayette formation of the South. This conclusion was reached tentatively more than a year since."

In the report for 1895 Professor Salisbury points out that the base of the Pensauken formation dips to the southeast in harmony with the Miocene and also inclines toward Delaware river. He also somewhat doubtfully refers the Fish House clays to the Pensauken. The Pensauken formation in the trough extending from Raritan Bay to the Delaware river, as well as the Pensauken formation southward along the southeastern bank of the Delaware are here mapped. On this map a large body of gravel found south of a line extending from Philadelphia to Atlantic City is represented as Pensauken, and so stated in the report. A number of sections are given to make clear his conception, in which the profile distinctly shows a marked difference in the elevation of the Pensauken from its lowest position near the Delaware river to its highest altitude in the vicinity of Glassboro and neighboring points. To account for this topographic difference a number of hypotheses are suggested, such as monoclinal folding, faulting, or possibly a bifold division of the Pensauken formation. In this connection he says: "From sections 2, 3 and 5 it would appear that the Pensauken might be a bifold formation." But he still regarded the whole as Pensauken, for he further says: "Indeed on any interpretation, the original continuity of the Pensauken across this belt seems certain, for occasional small remnants of it are still found."

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[1] *Annual Report of the State Geologist of New Jersey for* 1891.

In the report for 1896, Professor Salisbury no longer regards the Pensauken as being equivalent to the Lafayette, but places it in early glacial time. On the Mt. Pleasant hills he states the Pensauken formation probably lies as high as 178 feet, and suggests that these gravels may be a landward deposit of Pensauken streams.

He also places in the Beacon Hill formation the topographically higher member of those gravels found in the vicinity of Glassboro which, in the previous year, he had regarded as Pensauken. He also publishes a map and a section where this change in classification is recorded. The southward dip of the Pensauken is reaffirmed and the statement is made that the base of the Pensauken formation at times extends down below tide.

In the report for 1897, Professor Salisbury publishes a map in which he again changes his classification in southern New Jersey. The high gravels occurring in the vicinity of Glassboro, which he had first mapped in 1895 as Pensauken, and later in 1896, as Beacon Hill, he now places in three distinct formations, namely: Miocene, Beacon Hill, and Bridgeton; the Beacon Hill being younger than the Miocene, and the Bridgeton younger than the Beacon Hill but older than the Pensauken. In this connection he says: "The differentiation of the Bridgeton formation has been long in mind, though data for its sharp definition have been wanting. Even now they cannot be said to be altogether satisfactory. In some places the formation seems not to be clearly separable from the Beacon Hill formation which preceded, while in others it is not easily distinguished from the Pensauken which follows. In other places, on the other hand, it is distinctly separable from the Pensauken, and in still others from the Beacon Hill. The only question, therefore, concerns the integrity of the formation as a whole, and the data at hand do not demonstrate that that part of the formation which seems to be closely allied to the Beacon Hill formation is not really a part of that formation, and that that part which is with difficulty separated from the Pensauken, is not really Pensauken. On the other hand, these two parts, the one of which seems to have affinities with the Beacon Hill formation and the other with the Pensauken, seem to belong together. . . . . . .

"In general it (Bridgeton) may be said to contain any sort of material which the Beacon Hill formation contains, and some which it does not. It is therefore most clearly separated from the next older formation by its constitution. But occasionally its constitution closely approaches that of the Beacon Hill formation, and where its topographic relations are at the same time indecisive, its differentiation is uncertain.

"From the Pensauken, on the other hand, it is most clearly separated on topographic grounds, especially in the western part of the State. Here the Bridgeton beds lie at a level distinctly above that of the Pensauken beds, the latter being restricted to the low area west of the Miocene escarpment. The topographic relation of the formations indicates a long interval of erosion between their deposition. . . . . . .

"Some idea of the former extent of the Bridgeton beds may be gained if all existing remnants of it be conceived to be extended until they merge into one another, bridging the areas intervening between the existing remnants. It is believed that the formation extended much less far north than that which preceded, though the original limits are probably not determinable.

"It is altogether possible that some of the areas mapped as Bridgeton, west of the New Jersey Southern Railway, may prove to be Beacon Hill instead, and that some of the areas east of that line may prove to be Pensauken. The distinction in the latter area is based almost wholly on topographic grounds." He again mentions a tilting of the Pensauken formation and correlates the Pensauken with Kansan or Albertan.

A Pleistocene formation much discussed by Professor Salisbury in New Jersey is the Jamesburg.

His conclusions regarding the Jamesburg formation may be briefly stated as follows: In the report of 1893, it appears that the Jamesburg was deposited on the eroded surface of the Pensauken. It is aquatic in origin, and the subsidence which made possible its deposition amounted to at least 130 feet. The name is derived from Jamesburg Junction, in Middlesex County. A difficulty is encountered, however, in the absence or obscureness of a shore line for the Jamesburg sea. The material making up the Jamesburg formation is very much like that going to make up the Pensauken. Professor Salisbury states: "In some places the weathering of the latter (Pensauken) might have given rise to the overlying bed, which is here classed as Jamesburg." He states that there is in the Jamesburg an absence of the materials which in the Pensauken are decomposed, such as granites, gneisses and schists, as well as the Triassic shales and sandstones, which are commonly found in the Pensauken. The age of the Jamesburg is made equivalent to that of the Columbia or a part of it, for he said: "The Jamesburg is, therefore, but a local name for the Columbia formation, or for a part of it." It is correlated with an early glacial epoch, and Trenton and Trenton Junction are given as excellent localities for the Jamesburg.

In his report for 1894, Professor Salisbury regards the Jamesburg as a mantle, covering the country up to 214 feet or more. He considers it corresponding in a general way to the high-level and low-level Columbia, but that the Columbia of the South is believed to include more than the Jamesburg of New Jersey. The Jamesburg not only covers the bottom, but is found lapping up on the sides of the trough between Raritan Bay and the Delaware River with a distribution as wide as that of the Pensauken. It is unconformable on the latter and on older formations. Near Cream Ridge, the Jamesburg is stated as occurring at 214 feet and near Marlton 180 feet.

The Jamesburg is now divided into high-level and low-level Jamesburg. The relations of the high-level Jamesburg are very obscure, the low-level Jamesburg seems somewhat easier to recognize. In regard to the high-level Jamesburg, Professor Salisbury says: "The high-level Jamesburg is often very thin. Where it rests on the Pensauken it frequently has the appearance of being but the weathered part of the latter, so that it is often very difficult to distinguish between them on lithological grounds. So true is this that study had been long in progress before the existence of the 'high-level' Jamesburg over the higher areas of the Pensauken were regarded as demonstrated. The great body of facts now in possession, however, has put the existence of this phase of the formation beyond question. This statement is made with full recognition of the fact that good observers might see scores of sections of Jamesburg and Pensauken, the one over the other, without suspecting a subdivision, unless attention was especially directed to the matter. Even then it is probable that nine sections out of ten, or perhaps forty-nine out of fifty, would fail to be convincing on lithological grounds. But the tenth section or the fiftieth is conclusive, and carries the other nine or forty-nine with it."

The Jamesburg is poorly stratified and often contorted as if by lateral pressure. The limits of the high-level Jamesburg are upwards of 214 feet, and the low-level Jamesburg are 45 feet, the latter being deposited in rude terraces. The surface of the Jamesburg is pointed out as being frequently marked with low ridges and saucer-like depressions. The low-level Jamesburg is considered in part at least younger than the high-level Jamesburg.

In the report for 1895 Professor Salisbury states that the Jamesburg formation is very difficult to distinguish, and its existence has been called in question in many places. In this connection he says: "It should perhaps be stated that the existence of the Jamesburg has been called into question at many points. Lithologically it so closely resembles what might be produced from the weathering of the underlying beds, that at many points and over considerable areas, its existence could not be affirmed on the basis of facts there represented. But there are various points, on the other hand, and these widely distributed, where the Jamesburg formation is represented by a thin stratum, which could not by any possibility have been derived from the underlying formations, and the certain presence of the Jamesburg in such places is sufficient to carry the doubtful areas so situated that they cannot have escaped the influence of the agencies which made the deposits about the interpretations of which there is no doubt." He also states that the low areas about the coast are probably low-level Jamesburg, and are equivalent to the low-level Columbia, and in part contemporaneous with the Trenton gravel.

In the report for 1896 under the head of post-Pensauken submergence, Professor Salisbury mentions the 40-foot terraces, and also terraces as high as 200 feet on the Mt. Pleasant hills, as being deposited by streams which emptied into the sea, when the 40-foot terrace was being formed, and therefore the up-stream portion of the 40-foot terrace.

In 1897 the Cape May formation is defined as developed in terraces running from 30 to 50 feet in height. It is regarded as part glacial and perhaps in part younger. It is named from Cape May county, New Jersey, where it is typically developed and is regarded as including much of the low-level Jamesburg, and also much of the Trenton gravel.

The high-level Jamesburg (High-Level Loam) is still recognized, but the statement is made that it cannot be mapped. Professor Salisbury suggests that the high-level Jamesburg is a part of the Cape May formation, and represents a brief subsidence of the Coastal Plain of that region, amounting to 200 feet or more, at the close of the last glacial period. He also states that the formation is very hard to distinguish and difficult to be sure of.

A later view was expressed by Professor Salisbury on December 28, 1900 when, in the course of official correspondence with the Maryland Geological Survey, he said: "You will notice that in the later reports I have not used the word Jamesburg. . . . . . . I now regard it as a phase of the Cape May formation."

Views of the Writer.

For a number of field seasons, the author of this paper has been engaged in the investigation of the surficial deposits of Maryland. Reconnoissance work has been extended over the entire Coastal Plain, and a number of counties have been already mapped in detail. In pursuing these investigations, he has made free use of the methods of homogeny, and the correlation of the deposits thus established has necessitated not only the introduction of some changes in the classification and interpretations as suggested by Mr. Darton, but also has shown that the classification adopted by Prof. Salisbury for the New Jersey area is in no measure applicable to Maryland.

The key to the solution of the relations existing between the surficial deposits of Maryland lies almost exclusively, according to the author, in a correct correlation of the various terraces in which they are developed throughout the Coastal Plain. In Maryland, five principal terraces are distinguished, lying one above the other, the oldest occupying the highest, and the youngest, the lowest portions of the region. Beginning with the oldest and enumerating them in succession, we have what the author has designated as the Lafayette, Sunderland, Wicomico, Talbot and Recent. The Recent terrace is the one which the present sea is building.

A correct understanding of the physiographic features of the terraces may be obtained by studying the manner in which this recent terrace is forming. At the present time the waves of the Atlantic Ocean and Chesapeake Bay are engaged in tearing away the land along their margins and in depositing it on a sub-aqueous platform or terrace. This terrace is everywhere present in a more or less perfect state of development, and may be found not only along the exposed shore, but also passing up the estuaries to their heads. The materials which compose it are extremely variable, depending not only on the detritus directly surrendered to the sea by the land, but also on the currents which sweep along the shore. Along an unbroken coast, then, the material has largely a local character, while near river mouths the terraces are composed of debris contributed from the entire river basin. Where the waves are weak, partially decayed material is torn from the bank and re-deposited practically unharmed on the surface of the terrace, and continues, unchecked, its process of decay.

In addition to building a terrace, the waves of the Atlantic and Chesapeake are cutting a sea cliff along their coast line, the height of this cliff depending not so much on the force of the breakers as on the relief of the land against which the waves beat. A low coast line yields a low sea cliff and a high coast line the reverse, and the one passes into the other as often and as suddenly as the topography changes, so that as one sails along the shore of the Chesapeake, high cliffs and low depressions are passed in succession. The wave-built terrace and the wave-cut cliff then are constant features along the entire extent of the Bay shore, and should be sought for whenever other terrace surfaces are investigated.

In addition to these features, bars, spits and other formations of this character are frequently met with. Were the present coast line to be elevated, the sub-aqueous platform which is now building would appear as a well-defined terrace of variable width with a surface gently sloping toward the water. This surface would fringe the entire Atlantic and Bay shore as well as that of the estuaries. The sea cliff would at first be sharp and easily distinguished, but as ages passed the less conspicuous portions would gradually yield to the leveling influences of erosion, such as soil creep, plant roots, cultivation, etc., and might finally disappear altogether. Erosion would also destroy in a large measure the continuity of the formation, but as long as portions of it remained the old surface could be reconstructed and the history of its origin determined.

It was with these features well in mind that the author undertook the investigation of the surficial deposits in Maryland, and it was found that they supplied the necessary clue to their interpretation. Without entering into many details it may be briefly stated that the oldest terrace, the Lafayette, is found as outliers on the eastern edge of the Piedmont plateau from Washington across Maryland and Pennsylvania to New Jersey. The elevation of these deposits varies from about 500 feet behind Washington, as determined by Mr. Darton, to about 300 or 400 feet in the vicinity of Philadelphia, where it has long been known as the Bryn Mawr gravel. Besides these outliers of the Lafayette on the Piedmont plateau, there are others on Elk Neck occupying a lower elevation, and still another and more extensive area on the Coastal Plain immediately southeast of Washington. This area has already been reported by Mr. Darton, but it has been found after careful investigation that in place of extending down the peninsula to the Chesapeake Bay, it ends in an abrupt, low, scarp line, which may be seen in the vicinity of Charlotte Hall, in St. Mary's county, and at numerous other localities. No Lafayette is known to exist, however, on the peninsula of Calvert county. The elevation of the Lafayette at this scarp in southern Maryland is about 270 feet.

The next younger formation, the Sunderland, is extensively developed throughout Prince George's, Charles, St. Mary's and Calvert counties, and numerous outliers exist on other parts of the western shore from Herring Bay to Elkton, but the continuity of the formation in this portion of the State has been destroyed. This formation is developed as an unmistakable terrace butting up against the Piedmont plateau or lapping around the edges of the Lafayette. The scarp line at Charlotte Hall is part of the ancient sea-cliff of the Sunderland sea.

The materials composing it are extremely diverse, and embrace ice-borne boulders, gravel, sand and loam, which change their mutual distribution both vertically and horizontally, after the manner of shore deposits. They are frequently much altered and decayed, and have been derived not only from formations occurring in the immediate vicinity, but also from those found far west in the mountains. In southern Maryland the base of the Sunderland terrace lies at about 90 feet, but rises gradually toward the northwest, until at Charlotte Hall the surface of the bench is found at 170 feet. The name of this formation is derived from the hamlet of Sunderland, situated on the divide, in Calvert county.

After the deposition of this terrace, the country was raised and the Sunderland formation suffered greatly from erosion, but on the submergence of the region, the rivers which had found their way across its surface were transformed into estuaries, and the waves of the Wicomico sea beat on the exposed shores of the Sunderland terrace, and in their turn cut cliffs along its margin. After sufficient time had elapsed to build up a wide terrace, the country was again elevated and subjected to erosion.

What has just been said regarding the materials which enter into the Sunderland formation applies equally well to those composing the Wicomico terrace, except that it possesses perhaps a larger proportion of sand and loam derived from its sub-terrane. In southern Maryland the base lies at about 40 or 50 feet, and the top, where it borders its ancient sea-cliff at about 90 feet. Wicomico river in St. Mary's and Charles counties suggested the name for this formation.

The Talbot formation is developed as a bench of variable width around the edges of the Wicomico terrace, and frequently separated from it in many places by a low scarp line. Occasionally this scarp, which is the ancient sea-cliff of the Talbot sea, attains a height of 30 to 40 feet, notably in Kent county, but on the other hand, there are localities where the scarp seems to be entirely lacking, and it is probable that in these places it has been destroyed, since its elevation, in the manner described above. The Talbot formation was built up during a slight subsidence which followed the elevation and erosion of the Wicomico terrace. Large areas of the Wicomico and Talbot formations have been mapped on the Western Shore, but it is on the Eastern Shore of Maryland that they attain their most extensive development.

Any sort of detritus which enters into the other terraces may be found in the Talbot, but it possesses a greater proportion of loam and a smaller proportion of decayed materials than is found in the other members of the series. It also contains numerous lenses of greenish-blue clay, which frequently carry plant remains and are regarded as swamp deposits, formed in the mouths of ponded streams, and buried by the advancing beach of the Talbot sea. The famous Cornfield Harbor clays, carrying remains of marine and brackish water animals, as well as similar deposits five miles south of Cedar Point, in the same county, are also referred to the Talbot formation. The base of the Talbot terrace is irregular, sometimes lying above tide and sometimes below, but the top, where it borders its sea-cliff, is usually limited by the 45 or 50-foot contour.

A large number of terraces are cut in the Wicomico-Talbot surfaces by the streams along whose borders they lie, and it was not until after many profiles from various and distant regions had been compared that the 45-foot contour was determined to be the one which marked the shore of the Talbot sea. The name of this formation is derived from Talbot county, on the Eastern Shore of Maryland.

After the deposition of the Talbot terrace, the Coastal Plain was elevated somewhat higher than it is to-day, and remained in that position long enough to permit the rivers which flowed across it to cut rather deep channels, and its present position indicates a subsidence sufficiently great to drown these rivers and many of their predecessors toward their seaward portions. The Recent terrace is to-day building along the shore, and cutting its sea-cliff indiscriminately in the Talbot, Wicomico and Sunderland formations.

From the preceding discussion it will be seen then that the classification adopted by the Maryland Geological Survey recognizes four, distinct, mapable terraces in Maryland, in place of three as represented by Mr. Darton in the region of Washington, and differs from him in ascribing the formation of the divides of the peninsulas of southern Maryland to a formation younger than that of the Lafayette. Although the Wicomico surface rises gradually from an elevation of 90 feet in southern Maryland to about 140 feet behind Philadelphia, yet the distribution of the terraces does not seem to the author to indicate the complicated tilting described by Mr. Darton, but on the contrary points to the following course of events. Miocene elevation and erosion; subsidence and the deposition of the Lafayette formation; elevation and extensive erosion; subsidence and deposition of the Sunderland terrace around the edges of the Lafayette; elevation and erosion; subsidence and deposition of the Wicomico terrace about the margin of the Sunderland; elevation and erosion; depression and deposition of the Talbot about the margin of the Wicomico; elevation and partial erosion of the Talbot; subsidence and the deposition of the Recent terrace about the edges of the Talbot.

It is interesting in looking at a map of these various terraces to see how repeatedly the present estuaries have been transformed from rivers to fjords and back again to rivers, for one may trace the Sunderland, Wicomico and Talbot terraces up the valleys of all the principal streams to the Piedmont Plateau.

The unconformity which was described by Mr. McGee in the Sixteenth street cut, to which reference was made earlier, is not regarded by the author as pointing to a period of elevation and subaerial erosion, but simply as indicating a change of current or possibly freshet conditions and therefore in no way differing from the unconformities in a cross-bedded deposit except in the size of the materials moved. Both the restricted area in which this unconformity is found, as well as its position at the head of the old delta near the mouth of the Potomac gorge where the current must have been constantly changing, point to this conclusion.

A comparison of the section proposed by the author with that formerly suggested by Mr. Darton is as follows:

Darton.	*Shattuck.*	
Later Columbia	Talbot formation. Wicomico "	Columbia Group.
Earlier Columbia	Sunderland "	
Lafayette formation	Lafayette "	

After a careful study of the surficial deposits in Maryland an attempt was made to correlate them with the formations of New Jersey, belonging to the same period of deposition, as mapped and described by Professor Salisbury.

An extended excursion was therefore made in New Jersey in the autumn of 1900, but satisfactory correlations were found impossible. The difficulty encountered did not arise from the lack of contemporaneous deposits but from the fundamentally different classification adopted by the New Jersey Survey. The author found that with the exception of the Lafayette, the terraces were all present and as strikingly developed in New Jersey as in Maryland, and that they were distinguishable not only in the region of Bridgeton but across the entire Coastal Plain to South Amboy. The Maryland classification then, if applied to Delaware and New Jersey, would still indicate Talbot, Wicomico, and Sunderland, each developed in a distinct terrace and bearing the same mutual relations which they do further south.

The author was unable to detect any evidence of such a deformation as that described for the Pensauken, but on the contrary the levels at which the various terraces appear were found to agree very closely with those occurring in Maryland.

It was further observed that wide areas composed of re-worked marl, falling within the Wicomico formation and building part of its conspicuous terrace, were left unmapped, except where they developed a gravelly phase, when this material was entered as Pensauken.

Wherever the Jamesburg formation was examined it was the belief of the author that the phenomena could be better explained by hypothecating changes in the force and direction of the shore currents than by an appeal to a sudden subsidence of the entire region of more than 200 feet near the close of the Pleistocene, and as sudden an elevation afterward. The author, from his study of the region from the Potomac to the Raritan, is convinced that the Jamesburg materials described are present in each of the Pleistocene formations and evidently represent special physical conditions, not an independent formation.

Without going into more details it is evident that the correlation which the author has employed in Maryland is fundamentally different from that employed by Professor Salisbury in New Jersey. A comparison of the two systems of classification would give the following results:

COMPARATIVE TABLE OF MARYLAND AND NEW JERSEY PLEISTOCENE FORMATIONS.

Maryland Section.	*New Jersey Section.*
Talbot (lower portions of Later Columbia).	Parts of Cape May and Pensauken.
Wicomico (higher portions of Later Columbia).	Parts of Cape May, Pensauken and possibly Bridgeton.
Sunderland (Earlier Columbia).	Parts of Cape May, Pensauken and Bridgeton.

It is believed by the author that the methods of classification employed in Maryland are the natural ones, and that they will ultimately be found applicable to the determination of the marine Pleistocene deposits of much of the Atlantic Coastal Plain.

JOHNS HOPKINS UNIVERSITY, *May* 21, 1901.

OBSERVATIONS OF EARTHQUAKES.

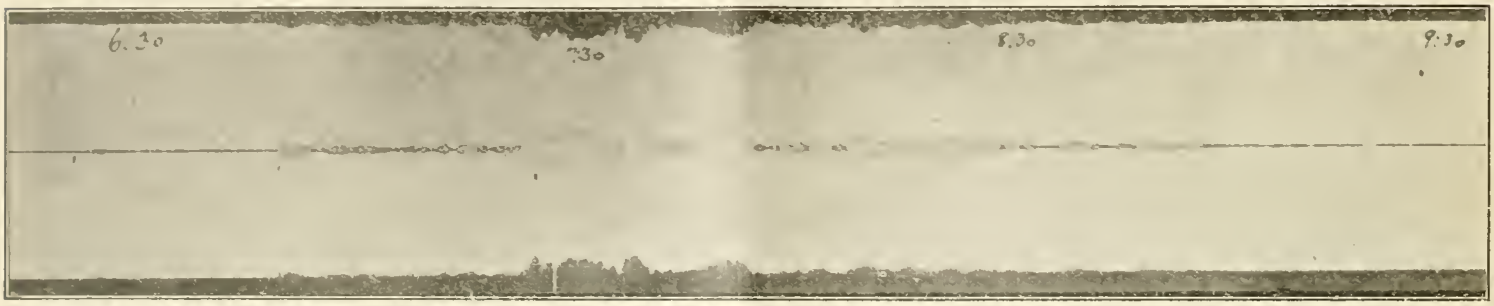
By PROFESSOR H. F. REID.

A seismograph of the form designed by Professor John Milne, F. R. S., has been installed in the Geological laboratory for the purpose of recording the times and characters of earthquake disturbances.

The instrument consists of a so-called horizontal pendulum, that is, a beam supported by a vertical column as a door is hung by its two hinges. The line between the two points of support of the beam is nearly but not exactly vertical; the more nearly vertical it is the more sensitive is the beam to slight tremors. It will be readily seen that any small tilting of the column at right angles to the beam will cause the latter to swing in that direction. The adjustment is usually made so that a tilting of the column of $\frac{1}{2}''$ of arc (*i. e.* a movement of the top of the column which is about 1 foot high, of $\frac{1}{35000}$ of an inch beyond the base) will cause the end of the beam to swing a distance of $\frac{1}{25}$ inch. The beam is 37 inches long, and on its end is fastened a small plate of thin brass in which is a narrow slit parallel to the length of the beam: this plate moves over a fixed brass plate with a similar slit, but at right angles to the former. A ray of light is reflected through the two slits which simply serve to narrow it and moves to and fro as the beam swings. The light falls on the photographic paper which is steadily moved by clock-work under the slits at the rate of 1 mm. (one twenty-fifth of an inch) a minute. When the beam is at rest the movement of the paper causes the light to trace a straight line upon it, but when the beam swings back and forth the straight line is changed into a sinuous curve. The period of vibration of the beam is about fifteen seconds, during which time the paper has only moved about a one-hundredth of an inch; consequently the curved line is very much compressed and its back and forth tracing on the paper appears like the widening and paling of the original straight line.

The instrument is mounted on a solid brick pier, built about 25 years ago in the basement of what was then the physical laboratory. The pier stands on the clays and gravels of the Potomac Formation, which rest on crystaline rocks seventy or eighty feet below the surface. The beam points about S. 30° W. This direction was chosen so that the beam might be parallel to the Appalachian mountain system and to the coast line and thus be most sensitive to disturbances propagated at right angles to these important continental features.

The seismograph was first put in adjustment on the morning of April 5, and late in the afternoon of the same day an earthquake occurred which left the record shown in the accompanying figure.



It will be noticed that the movement commenced at 5:52½ p. m. (standard time, 75th meridian) and was very slight for about 27½ minutes; this was followed by distinctly stronger movements for 32½ minutes. Then came the strongest movements lasting for more than an hour; and the disturbance gradually subsided, ending after 9:37.

This is the typical form of earthquake records and consists of an interval of preliminary tremors followed by the stronger disturbance which gradually subsides. Mr. Oldham, of the Indian Geological Survey, holds that records of important earthquakes show at a distance from the origin three phases; the first two being due to distortional and compressional waves propagated through the body of the earth, and the third, to which our instrument is most sensitive, to long waves propagated around the surface. It will be noticed that our record shows three phases very distinctly.

The interval of time between the beginning of the record and the arrival of the long waves is a good indication of the distance from the origin; our record points to an origin about 120° distant. I have received communication showing that this same earthquake was recorded on instruments of the Milne type at Kew, Shide (Isle of Wight), Toronto, and Victoria, B. C. The long waves arrived at Shide, Toronto and Baltimore about the same time, but were sixteen to eighteen minutes earlier at Victoria. We can therefore place the probable origin of the earthquake in the western part of the Pacific ocean, perhaps not far from the Philippine islands. That this earthquake was recorded at such widely separated stations as those mentioned illustrates the well established fact that earthquakes, even when not very violent, produce over the whole world disturbances strong enough to be detected by proper instruments. It is rather curious, that this earthquake, which could not possibly have been felt in Baltimore, has made so good a record, whereas our instrument has not given the slightest indication of an earthquake reported to have disturbed people in Ohio and West Virginia, in the early morning of May 17th. It is possible that the vibrations of the latter were too rapid to affect our instrument, which although extremely sensitive to slower movements is not affected by the rapid jars due to electric cars or even by the trains passing through the Baltimore and Ohio Railway tunnel about 150 feet distant.

THE JOHNS HOPKINS PRESS OF BALTIMORE.

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NOTES FROM THE PHYSICAL LABORATORY.

EDITED BY PROFESSOR JOSEPH S. AMES.

SOME FURTHER EXPERIMENTS UPON THE RELATIONS BETWEEN ETHER, MATTER AND ELECTRICITY.

By N. E. GILBERT.

[Abstract of Dissertation submitted for the degree of Doctor of Philosophy, prepared by J. S. Ames.]

In the *University Circulars* for June, 1900, an account was given of some experiments designed to see if the electrical resistance of a coil of wire varied when the magnetic field which ordinarily accompanies an electric current was neutralized by the action of a second coil. If there had been any such variation, it would have been explained by a frictional resistance to motion of the ether. No such effect, however, could be detected.

It was suggested by Professor Rowland, that it was possible that, if a linear conductor be moved rapidly in the direction of its own length, there might be generated in it an E. M. F. between its two ends, owing to some difference between the nature of positive and negative charges. If such an E. M. F. could be shown to exist, the main features of the magnetism of the earth would be explained, assuming that these electromotive forces in the rotating earth produce a magnetic field equal to that which would be produced by true conduction currents caused by equal electromotive forces applied in the stationary earth. From a knowledge of the existing magnetic field of the earth it is easy to calculate the necessary relation between this hypothetical E. M. F. and the average conductivity of the earth in order to account for the phenomena.

Assuming that the E. M. F. produced in a wire moved in the direction of its own length varies directly as the length of the wire and as its velocity, and calling the factor of proportionality κ, and the average specific resistance of the earth ρ, it is found that $\frac{\kappa}{\rho}$ must equal about 13×10^{-15}, practical units, in order to satisfy the conditions.

An experiment was accordingly devised to determine first, whether there is such an E. M. F. produced by moving matter, secondly, the magnitude of the factor κ, provided it is measureable. A wheel was made " whose periphery was a cylinder 4.2 cm. broad and of 7.3 cm. radius. On this was wound in a single layer 175 turns of No. 33 copper wire giving a resistance of 57 ohms." The terminals of this wire were connected to the poles of a sensitive galvanometer by brushes on the axle, silver wires being used for several inches in both directions from the brushes in order to avoid thermal currents. The wheel was run by a belt from a one-sixth horse power electric motor; and a speed of 150 revolutions per second could be obtained easily. All ordinary precautions were taken, and all the conditions were varied. A purely negative result was obtained in all cases. In one series of experiments lasting over six weeks, the mean result of 920 readings was a deflection of 0.02 mm. on the galvanometer scale, which corresponded to $\kappa = 7.5 \times 10^{-17}$ volt. In a different series conducted eight months later, a result in the opposite direction was obtained, of about the same numerical value.

The experiment was varied also by placing a heavy copper shield around the wheel, by placing an electric charge on an insulated brass shield surrounding the wheel, etc., but in no case was there any measurable definite deflection of the galvanometer, however sensitive it was made.

PRESSURE SHIFT OF CADMIUM λ 4800.

By W. B. HUFF.

In connection with the study of the shift of the spectrum lines under pressure which was made in this laboratory by Humphreys and Mohler, the question has been raised as to whether the shift of the lines from one substance is dependent on the amount present, and whether it is affected by the presence of other substances.

The fact that a large amount of material in an arc at atmospheric pressure caused a slight shift had been noted by Mr. L. E. Jewell. The conclusions reached by Humphreys and Mohler from a consideration of the spectra of impurities in the poles was that the amount of material present was not important, the shift depending on the total pressure rather than on the density of the vapor under consideration.

At the suggestion of Professor Ames, the writer undertook a study of the question, using cadmium, either pure or in the form of an alloy, with zinc or lead. The apparatus was essentially that used by Humphreys and Mohler. It included a heavy iron cylinder to contain the air under increased air pressure; the 21 foot concave grating was used, giving in the second order a dispersion of about 1 mm. per Ångström unit. The camera was arranged with a shutter, so that the middle of the plate showed the line under increased pressure; above and below this was the line as ordinarily seen.

It was necessary first to find the minimum amount of cadmium which could be detected in the presence of the other metal used. The alloys were made before the metals were placed in the arc, special care being used to insure uniform composition. It was found not difficult to detect one-tenth of one per cent. cadmium in zinc, but the zinc oxide which was found shut out the light so quickly that at least one per cent. of cadmium had to be used in order to photograph its lines. With lead more cadmium was needed, the lead being specially effective in blotting out the lines of other substances. Using an alloy as one pole, the oxides prevented sufficient exposure. If but a small amount of alloy was used on a pole of carbon or iron, it burned away too soon. The only way of obtaining lines which were fine, yet which could be seen for the necessary time, was by using small amounts of metal placed at the bottom of a hole about 2 cm. deep, bored in a carbon pole.

Under pressure the line became slightly broader, but this broadening seemed to be symmetrical. There was also a tendency to reverse, as has been pointed out by Humphreys and Mohler. In order to avoid the question as to equality of shift for sharp and reversed lines, no reversal was used.

The outside exposure was usually double, once before and again after the exposure for shift. This necessitated a fine line, since for a broad one an accidental displacement of the camera would remain undetected. After such double exposures, eye observations showed that the cadmium lines were still visible.

The cadmium line $\lambda = 4800$ obtained from cadmium in the carbon pole was compared with the same line from cadmium containing a small percentage of zinc, and from a small amount of cadmium in lead or zinc, the alloy in a carbon pole.

An examination of about forty plates shows that for a large percentage of cadmium in the arc, the displacement increases regularly with the pressure, but not linearly. Plates taken when there is but little cadmium in the arc show a shift which is decidedly erratic, the same increase of pressure showing in some cases two or three times as much shift as in others. This variation seems to be due to the small amounts of metal present rather than to the effect of the other component of the alloy. Since the plates were taken in no special order, accidental disturbances of apparatus can hardly have caused the differences. The exposures usually lasted from about half a minute to a minute, depending upon the amount of metal used. The difficulty of keeping the arc burning and the formation of the vapors made any very accurate determination of time of exposure impossible. Of course, the longer exposures led to greater heating and consequent rise in pressure. The recorded pressure was the mean of the initial and final pressures, which rarely differed by as much as one atmosphere.

It should be said that many more plates were taken than were measured; but in no case was a plate rejected merely because it showed an unexpected shift.

ON THE MAGNETIC EFFECT OF ELECTRICAL CONVECTION.

By Harold Pender.

From a series of experiments extending over the last four years, M. V. Cremieu[1] has come to the conclusion that a moving electrified body produces no magnetic effect. This conclusion is in direct opposition to the classical experiment performed by Prof. Rowland[2] in Berlin, in 1876, which was subsequently repeated in this laboratory by Prof. Rowland and C. T. Hutchinson[3] in 1889, and confirmed also by experiments performed by Röntgen[4] and Himstedt[5] in Germany. A further investigation of this very important question was therefore considered advisable. Accordingly in the fall of 1900, under the supervision of Prof. Rowland, the following research was undertaken. As a result, it has been shown conclusively that electrical convection does produce magnetic action.

There are two methods of putting in evidence the magnetic effect of electrical convection. In the first, employed by Rowland, Röntgen, and Himstedt, the action of a rapidly rotating charged disc on a delicate magnetic needle suspended near it is observed. A second method, due to Cremieu, is to measure, by means of a delicate galvanometer, the current induced in a coil fixed near the disc, when the sign of electrification of the disc is suddenly reversed. The effect of a single reversal is extremely small, but a measurable effect can be readily obtained by charging and discharging the rotating disc a number of times a second, and commutating the current thus induced in the coil. Cremieu calculated that with the apparatus used by him a deflection of from 20 to 50 mm. should have been obtained. No such deflection was observed, however. Cremieu has also employed the magnetometer method, and with this method also his results have been negative.

In the following investigation the coil and galvanometer method only has been employed. The galvanometer which it was found necessary to employ was so exceedingly sensitive, that observations could be made only at night, when all traffic on the electric railways of the city had ceased—about two hours and twenty minutes each night. Other disturbing factors—the mechanical jarring of the rotating apparatus, and the direct electrostatic action of the charged disc on the delicate galvanometer system—proved a source of great difficulty, and were finally eliminated only after months of experimenting. So that, though an effect, unmistakably due to the magnetic action of electrical convection, was observed as early as December 22nd, it was not until the middle of March that accurate quantitative measurements were attempted.

To produce the convection current two micanite discs 30 cm. in diameter, gilded on both sides, were employed. These discs were mounted so as to turn about horizontal axes in the same line. Opposite each face of each disc, about a centimetre distant, was fixed a condensing plate formed by tin foil on ebonite. The condensing plates were connected to earth. The two discs were charged from a Voss machine and battery of six gallon Leyden jars, by means of brass brushes rubbing on brass rings, diameter 6 cm., fixed at the centres of the discs. Between the Leyden jars and the discs was an interrupter so arranged that the charge on the discs could be reversed a number of times a second, 12 to 25. The two discs were driven at a speed of from 75 to 100 revolutions per second by a 1 H.-P. motor 5 metres distant.

Between the two inside condensing plates was suspended a coil of 1295 turns of No. 21 copper wire, mean diameter 30 cm. This coil was completely enclosed in a metal case, connected to earth. The coil was connected through a commutating device to a sensitive astatic galvanometer of the ordinary four-coil form. The commutating device was driven by the same shaft as drove the interrupter, so that between each reversal of the sign of the electrification of the discs, the galvanometer terminals were reversed. In this way the alternating current induced in the coil was rectified before passing through the galvanometer, which therefore showed a steady deflection when the commutator was kept running at a constant speed. The entire galvanometer and coil circuit was enclosed in a metal shield connected to earth. The galvanometer was ten metres from the discs and five metres from the motors driving the discs, commutator, and Voss machine.

The period of the galvanometer needle was about 25 seconds. Its sensibility was such that a current of 1×10^{-10} amperes gave a deflection of 1 mm. on a scale 1.1 metres distant. The resistance of the galvanometer is 58.4 ohms, that of the coil 140 ohms.

There are two ways in which the above apparatus can be used. The two discs can be rotated in the same direction and at any instant charged alike, or they can be rotated in opposite directions, and at any instant charged oppositely. Both methods were employed, but the latter more frequently, as the galvanometer needle was much steadier under these latter conditions.

The direction of the deflection due to the charged rotating discs can be compared directly with that due to a conduction current, reversed in the same manner as the charge is reversed, flowing through a test coil fixed on the disc apparatus. This was done from time to time throughout the experiment, and the deflection was always in the direction to be expected according to Ampère's rule, *i. e.*, the motion of a positive charge always produced the same effect as that of a conduction current flowing in the direction of motion of the charge.

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[1] C. R., 130, p. 1544, 1900; 131, pp. 578, and 797, 1900; 132, p. 327, 1901.

[2] *Pogg. Ann.*, 158, p. 487. *Am. Jour. Sc.*, (3) 15, p. 30, 1878.

[3] *Phil. Mag.*, 27. p. 445, 1889.

[4] *Ber. d. Ber. Akad.*, 1885, p. 195.

[5] *Wied. Ann.*, 38, p. 560, 1889.

The strength of a convection current is defined as the quantity of electricity carried convectively past any point in unit time. On the assumption that a convection current is magnetically equivalent to a conduction current of the same strength, the current induced in the suspended coil on reversing the sign of electrification of the discs can be readily calculated from the dimensions of the apparatus and the difference of potential between the discs and plates. This calculated value of the current can then be compared with the observed value as deduced from the deflection of the galvanometer. The formula for the calculated value of the current involves the ratio of the two systems of electric units, so that instead of comparing directly the observed and calculated values of the current the two can be equated and the value of the ratio v thus determined. The value of this ratio thus found is a test for the accuracy of the assumption that a convection current is equivalent magnetically to a conduction current. From 17 sets of observations, each set consisting of 18 separate determinations of the deflection and the other quantities involved, the mean value of v thus found was 3.05×10^{10}, the determinations which differed from this the most being 2.75×10^{10} and 3.24×10^{10} respectively. The value of this constant is known to be 3.000×10^{10}. That the deflection observed was unmistakably due to the magnetic action of the rotating charged discs was shown in still another way. As was stated above, when the two discs are set rotating in the same direction and at any instant charged alike, or when they are set rotating oppositely, and any instant charged oppositely, the magnetic effects of the two on the coil are in the same direction. If, however, the discs rotate in the same direction and at any instant are charged oppositively, or rotate in opposite directions and any instant are charged alike, their magnetic effects on the coil should annul one another, provided the two discs rotate with the same speed. This is in perfect accord with observation. For example, when the two discs were rotating in same direction with speeds of -86.9 and -88.8 revolutions per second respectively and charged alike, the observed deflection was -66.2; when they were rotating oppositely under the same conditions, with speeds $+88.0$ and -89.6 the observed deflection was -1.0.

In all the preceding the surfaces of the discs and condensing plates were continuous. A series of observations was also taken with each of the discs and the condensing plates divided into six sectors by radial scratches $\frac{3}{4}$ mm. wide. If the effect observed were due in any way to conduction current in these surfaces this arrangement should certainly greatly alter its magnitude. This was by no means the case, as the values of v determined under these conditions were well within the range of accuracy of the experiment. The mean of four sets of readings under these conditions gave for the ratio v 2.96×10^{10}.

The above results, therefore, show beyond any doubt *that electrical convection does produce magnetic action*, or, more exactly, that when the sign of electrification of a moving charged body is changed, an electric conduction current is induced in a neighboring circuit, of a strength equal to that which would be induced in this circuit by reversing the direction of a conduction current in a circuit coinciding with the path of the convection current.

SOME PROPERTIES OF THE ELECTRIC SPARK AND ITS SPECTRUM.

By C. C. SCHENCK.[1]

The object of this investigation is two-fold: to divide the principal lines in the spark spectrum of cadmium into three groups, each having characteristics peculiar to itself; and to study some of the properties of the spark and its spectrum by means of photographs taken with a revolving mirror, with a view to tracing the connection between lines of different groups and certain phenomena in the spark itself, so as to throw some light upon the cause of the complexity of the spark spectrum as compared to that of the ordinary arc in air. The division of the lines into groups followed from a detailed study of the changes produced in the spark spectrum when the period of the condenser producing the spark was varied by increasing the self-induction of the spark circuit.

Kirchhoff[2] in 1861, and Thalen in 1866, stated, in a general way, the charges produced in spark spectra by inserting in the circuit containing the condenser and the spark gap, either a wet string or the coils of an electro-magnet. Hemsalech has done some work on the same subject and has recently suggested a division of spark lines into groups, which is not quite the same, however, as that proposed here, as it does not include the lines of the first Group C.

The spark was produced by a large induction coil whose primary was traversed by an alternating current. The condenser consisted of six gallon jars in parallel, with a total capacity of .016 microfarads. The spark length varied from 6 to 8 mm. The rotating mirror was driven by an air blast and its period was measured by an indicator geared to its axis. The period of the condenser was found by photographing the image of the spark in the revolving mirror and measuring the separation of the oscillations on the photographic plate. Its value was 1.3×10^{-6} seconds, when the spark circuit was as short as possible. Each spark consisted of 10 or 12 complete oscillations. The spectrum was photographed with the large concave grating of 21 feet radius. An examination of the plates showed that the lines could be separated out into three distinct groups with the following characteristics:

Group C. About 125 lines in the ultra violet extending from 2100 to 4300 Å. N., with the following characteristics:

1. They have a breadth of $\frac{1}{3}$ Ångström units, and their edges are hazy.
2. They extend only about 2 mm. out from the poles toward the center of the spark.
3. They are absent from the arc spectrum.
4. None of them are reversed.
5. When the period of the condenser was increased 13 times, *i. e.*, to 17×16^{-6} seconds, they disappeared from the spectrum while the other metallic lines were practically unaffected.

Group B. 20 lines commonly known as "spark lines," with these characteristics:

1. None of them are reversed.
2. They are either absent from, or else very weak in the spectrum of the arc in air, but prominent in the spark.

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[1] A preliminary note of this investigation was published in these *Circulars*, in June, 1900.

[2] *Abhandlungen der Acad.*, Berlin, 1861, p. 73.

[3] *l'Annuaire de l'Université d'Upsala*, 1866.

[4] *Jour. de Phys.*, Dec., 1899.

[5] *Comptes Rendus*, April 22, 1901.

3. When the period of the condenser was increased 58 times, *i. e.*, to 75 x 16^{-6} seconds, a few disappeared, while the rest shortened up close to the poles.

Group A. About 52 lines commonly known as "arc lines," with these properties:

1. Some are either extremely weak or absent altogether in the spark and strong in the arc. The others are prominent alike in spark and arc.

2. They extend clear across the spark gap when the period of the condenser is great enough (75 x 10^{-6}) to cause the lines of Group B to shorten up close to the poles.

3. An increase in the period of the condenser causes the spectrum formed by this group to become more complicated, especially in the ultra violet, and to approach that of the arc.

There is scarcely any doubt that the lines of Group A are due to luminous metallic vapors which fill up the entire spark gap; and the fact that this spectrum (Group A) becomes more complicated as we pass from the spark spectrum toward the arc spectrum by increasing the period of the condenser, renders it probable that the average temperature of the metallic vapors in the arc is higher then that of the vapors in the spark. At any rate the effect of increasing the self-induction of the spark circuit is a double action, a repressive effect upon the lines of Groups C and B, and an enhancing effect upon those of Group A, and its whole effect cannot be explained by saying merely that the spark is hotter than the arc; for the spark is a complicated mechanism, and the temperature not only varies from point to point, but is also a rapidly varying function of the time. 29 lines were omitted from the classification, a few not fitting in with any of the groups, while the rest were extremely weak.

In order to get a connection between the lines of different groups and certain phenomena in the spark, both the plain spark and its spectrum were photographed by means of a rotating mirror. The plain spark was photographed by placing a narrow vertical slit very close to it and allowing the light to fall upon a rotating mirror, with vertical axis, and thence through the lens of a camera.

The spectrum was photographed in two ways: First, by placing a narrow vertical slit very close to the vertical spark, and mounting at a considerable distance away, 231 cm., a single 60° prism of flint glass with its edge vertical; the prism was set at the angle of minimum deviation for wave length 4500, and the refracted light fell upon a rotating mirror, with horizontal axis, and was reflected through the lens of a camera, and the spectrum focussed on the ground glass. The height of the spectrum, *i. e.*, the length of its lines, was only .7 mm. By the rotation of the mirror the lines were pulled out in the direction of their length by an amount depending upon their duration and upon the speed of the mirror. Second, by placing the axis of the mirror vertical so that the spectrum lines were broadened in a direction perpendicular to their length.

The appearance of the plain spark presents three general features:

1. A brilliant white straight line, due to the first discharge, which is sometimes followed by one or two similar weaker straight lines at intervals of half the complete period of the condenser.

2. Curved lines of light which shoot out from the poles toward the center of the spark gap with a velocity constantly diminishing as they move away from the electrodes.

3. A rather faint light, generally of a different color from the curved lines, which fills up the spark gap and persists for a certain length of time after the oscillations die out, especially in the center of the spark gap.

These facts are well known.[1] Schuster[2] has likewise proved that it is the first brilliant discharge to which the air lines in the spark spectrum are due.

The photographs of the spectrum taken by the first method, with the axis of the mirror horizontal, brought out the following facts: the lines of Group B, strong spark lines, were sharply beaded clear out to their ends, as a result of the oscillations, while those of Group A, strong arc lines, showed only indistinct traces of beading which did not extend all the way out to the ends of the lines. The duration of the lines of Group A was more than twice as great as that of the lines of Group B.

Those taken with the axis of the mirror vertical, supplemented by visual observations, showed these phenomena:

The strongest spark lines (Group B) of cadmium and magnesium appeared in the form of a beautiful series of curved streamers corresponding exactly with the curved lines of light seen in the plain spark. The principal arc lines (Group A) also appeared in the form of a similar series of curved streamers, *not* very clearly defined, and they showed in addition a luminosity which filled up the entire spark gap and persisted, especially in the center of the spark gap, after the streamers had ceased.

These facts lead to the conclusions that the principal spark lines of cadmium and magnesium, *i. e.*, those lines that give to the spark spectum its complexity, as compared with that of the ordinary arc in air, are due entirely to the curved lines of light, or streamers, which are seen in the plain spark; that the principal arc lines (Group A) are due in part to the streamers and in part to a luminosity which fills up the spark gap and persists after the streamers cease.

This is also well shown by increasing the period of the condenser from 1.3 x 10^{-6} to 75 x 10^{-6}. In this case the streamers in the plain spark, when examined with the rotating mirror, do not advance so far from the poles as in the former case; the lines of Group B also show a corresponding tendency, as mentioned above, to shorten up close to the poles while those of Group A stretch clear across the gap.

The light which fills up the gap and persists after the oscillations cease is probably luminous metallic vapor. The nature of the streamers is not yet entirely clear; they may be luminous pulses merely; or they may be metallic vapors the peculiar vibration of whose atoms is produced by the act of tearing them off the electrodes; as they moved away from the poles the abnormal vibrations would die out while the more fundamental vibrations, principal arc lines, would persist, would indeed be augmented by the passage of the to-and-fro currents through the vapors.

These are some of their characteristic properties:

1. They proceed from the kathode (for magnesium).

2. They do not carry the current.

3. They are affected by a strong magnetic field, but experiments along this line have not yet been carried far enough to determine the exact action.

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[1] Feddersen, *Pogg. Ann.*, 116, 1862.

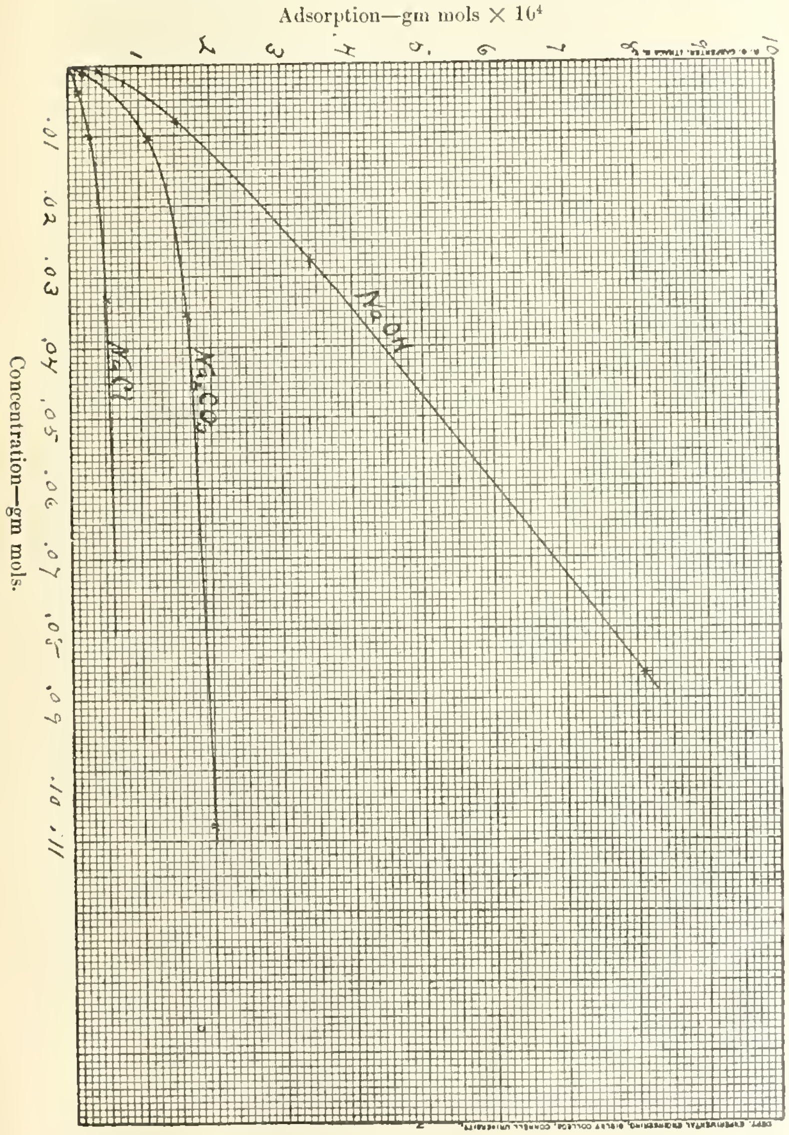
[2] Schuster, *Phil. Trans.*, 193, p. 209.

ON THE ADSORPTION OF WATER VAPOR, CARBON DIOXIDE, AND CERTAIN SALTS IN AQUEOUS SOLUTION BY FINELY DIVIDED QUARTZ.

By Lyman J. Briggs.

Solid bodies possess the property of retaining upon their surfaces small quantities of gases or dissolved substances with which the solid is in contact. To this phenomenon Dubois-Reymond has applied the term "adsorption."

As a consequence of the phenomenon of adsorption, the density of a gas, or the concentration of a dissolved substance is greater immediately at the surface of the solid than at a short distance outside. This is shown by the fact that when a solution of a substance is shaken with a finely divided insoluble solid for a sufficient period of time, the concentration of the clear supernatant liquid is less than that of the original solution. It has also been shown that the mass of gas contained in the interstitial spaces of a finely divided solid is greater than that corresponding to the given volume and pressure. Both facts point to a condensation of the gas or dissolved substance on the surface of the solid.



In the present investigation, vein quartz was used as the adsorping material. This was crushed mechanically to a very fine state of division, acidulated with hydrochloric acid, and thoroughly washed and dried.

Adsorption of Water Vapor.

In determining the adsorption of water vapor by quartz, a definite vapor pressure was secured by drawing air through a train of washing flasks containing an aqueous solution of sulphuric acid. The air with its water vapor then passed into a chamber containing the powdered quartz, which was constantly stirred, and thence through two safety-flasks to the filter pump. The train of sulphuric acid flasks, the quartz chamber and one safety flask were all immersed in a thermostat, to avoid precipitation of the water vapor. By changing the concentration of the sulphuric acid, any desired vapor pressure could be secured. The amount of water adsorbed was determined by transferring the quartz to a shallow weighing bottle, weighing, and then drying to constant weight, the loss being taken to represent the adsorbed water. It was found that for the vapor pressures investigated, the relation between the vapor pressure and the amount of water adsorbed was practically linear, the direction of the curve indicating considerable adsorption even when the vapor pressure was practically zero.

Adsorption of Carbon Dioxide.

The following method was used in determining the amount of carbon dioxide adsorbed by quartz. The quartz with its adsorbed gas was shaken with a solution of sodium hydroxide, which reacted with the adsorbed carbon dioxide, together with that existing in the vessel in the gaseous state. The mass of the latter was computed from the volume of free space and the partial pressure of the carbon dioxide. By titrating the sodium hydroxide solution before and after shaking with the quartz, the total amount of carbon dioxide in the flask containing the powdered quartz was found. The difference of these two determinations gave the amount of adsorbed carbon dioxide. The relation obtained between the pressure of the carbon dioxide and the amount adsorbed was similar to that found for water vapor, there being a marked adsorption even at the partial atmospheric pressure of carbon dioxide.

Adsorption of Dissolved Substances.

The chlorides, carbonates and hydroxides of sodium, potassium and ammonium were the principal salts employed. A series of five concentrations varying from thousandth-normal to tenth-normal solutions were prepared, and 150 cc. of each solution were shaken with 100 gms. of quartz at constant temperature until equilibrium was attained. The amount of adsorption was determined by titrating the solutions before and after shaking with the quartz.

The accompanying curves show the relation found between concentration and amount of adsorption, for sodium chloride, sodium carbonate, and sodium hydroxide. Similar curves were obtained for the corresponding potassium and ammonium salts. From this it appears that the amount of adsorption in the case of this series of salts is dependent upon the acid radical rather than upon the basic element.

It is also to be noted that the amount of adsorption is not, as was supposed by van Bemmelin and Schmidt, a linear function of the concentration if we take into consideration very dilute solutions. These investigators, however, employed concentrations above one hundredth normal, and for such there is an approximately linear relation between concentration and the amount of adsorption.

ON THE LIGHT SCATTERED AND TRANSMITTED BY FINE PARTICLES SUSPENDED IN SOLUTION.

By James Barnes.

The object of the following experiments, undertaken at the suggestion of Professor Ames, was to ascertain whether any relation existed between the light scattered and transmitted by fine particles suspended in solution, according as the number or size of the particles was increased.

After many experiments upon precipitates and solutions it was found that the particles formed, when a few drops of an alcoholic solution of mastic were added to a beaker of water, were very small, and that they remained suspended in solution. Neither did they appear to aggregate themselves together into larger masses. The glass vessel used was 25 x 18 x 14 cm. About one and a half litres of distilled water was placed in it, and small quantities of the mastic solution dropped in from a burette. A beam of sunlight from a heliostat was passed through the solution of particles. Two spectroscopes were used; one was placed so as to analyse the transmitted light, and the other perpendicular to the path of the beam to analyse the scattered light.

When the number of particles was not very great, the spectrum of the scattered light first showed the violet, blue and green. These colors seemed to appear at the same time. As the number of particles were increased the intensity of the scattered light increased, the Fraunhofer lines became visible, and the yellow and red appeared. In the transmitted light there was no sharp division; a gradual decrease in the intensity of the light beginning at the violet was obtained in the spectrum of the transmitted light as the particles increased in number. It was noticed that the beam at the end of its path was a less decided blue than at the beginning, and where the particles were very thick it was a dim red. The following method was employed to observe what part of the incident light was cut off in transmission, and how far a portion of a color or a wave-length penetrated solutions containing different amounts of mastic particles.

A beam of sunlight was passed through a Steinheil spectroscope with the telescope removed. The spectrum formed was thrown upon the end of the vessel used above, and after passing through fell upon a scale. The surface of the water in the vessel was adjusted to such a height that half the spectrum passed through the water while the other half passed through the air directly above. The spectrum obtained on the scale was therefore divided by a black horizontal line. By this means one could easily observe the portion of the incident light cut off in transmission. Looking into the solution from above, one could roughly observe how far each portion of color penetrated a solution. It is of interest to note that the red, yellow, and part of the green in the transmitted light kept the same intensity as that of the light which passed above the solution until the violet and blue had completely disappeared. Then the red, yellow and green together gradually lost in intensity, the spectrum shortening up very slowly. The results obtained indicate that a greater portion of the violet and blue part of spectrum is scattered per equal increase in the number of particles than in the longer wave-lengths of the blue and the green.

The following observations were made to obtain some idea as to how far certain wave-lengths of the incident spectrum penetrated solutions containing different amounts of particles. The results below were selected from a table giving the distance the wave-lengths near the "*h*" line ($\lambda = 41\ o\mu\mu$) penetrate the solutions.

Amt. of Mastic Sol. in Water.	*Distance Penetrated.*	*Amt. of Mastic Sol. in Water.*	*Distance Penetrated.*
2 cc.	24.5 cm.	7 cc.	7.5 cm.
3 cc.	17.0 cm.	8 cc.	7.0 cm.
4 cc.	12.0 cm.	9 cc.	7.0 cm.
5 cc.	9.5 cm.	10 cc.	6.5 cm.
6 cc.	8.0 cm.		

These results were plotted. The curve obtained gave the equation $xn^{2.5} = \text{const.}$ where x is the distance penetrated and n the amount of the mastic solution present and which is proportional to the number of particles present.

We know that

$$I = I_0 \epsilon^{-k\lambda^{-4}x}$$

where I_0 is the intensity of incident light and k a constant, and may be considered the absorption coefficient for the distance x of medium. For a given wave-length since in the above observations I and I_0 are constants,

$$x \text{ varies as } {}^1/_k.$$

Therefore, from equation of curve

$$k \text{ varies as } n^{2.5}$$

When the wave-length employed is longer, the exponent of n approaches unity and thus the absorption varies directly as the number of particles in solution.

A word in conclusion in reference to the polarization of the scattered light. The light scattered was at first perfectly polarized in a plane making an angle of 90° with the illuminating beam, but diminished as the number of particles in the solution increased.

NOTES ON THE ZEEMAN EFFECT.

By N. A. Kent.

It has been shown by H. M. Reese[1] that the separation of the external components of the regular Zeeman triplet or quadruplet, as seen perpendicular to the lines of force, does not vary proportionally with the strength of the magnetic field in which the luminous source is placed. This fact was established for various zinc and cadmium lines up to a field of about 26,000 c. g. s. units.

Reese also states, in referring to certain lines in the spectrum of iron, that, "In comparing the separation of the lines between 3900 and 4450 it was at once observed that the lines could be broken up into two classes in each of which the separation of the various lines was of the same magnitude. These two classes are identical with those for which Humphreys found that the shift due to pressure was the same. On these plates the separation is very small in all cases, owing to a weak field and no accurate measurements were taken of the separation."

It appeared then to be a matter of no little interest to extend Reese's investigations on zinc using higher field strengths; and also to make a more exhaustive investigation of the spectrum of iron and measure the separation with care. These two primary lines of study suggested others as given below.

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[1] *Astrophys. Journal*, Vol. XII, No. 2, Sept., 1900, pp. 120-135.

The apparatus used was essentially that employed by Reese:—A Rowland concave grating, radius of curvature 13 feet 3 inches, of 15000 lines per inch, fitted with the ordinary slit and camera box; Seed's "Gilt Edge," Cramer's "Isochromatic Fast," and the International Color Photo. Co.'s "Erythro" plates; an electromagnet giving a maximum field of 33,000 c. g. s. units for a 3 mm. gap; as luminous source, a spark between terminals of, or containing, the metals investigated—the spark being produced by an alternating current, of 133 cycles per second passed through an adjustable impedance and through a transformer, the secondary circuit containing a condenser which discharged across the spark gap, the leads to which were short thick wires (self-induction was used in the discharge circuit when it was desirous to remove the air spectrum or sharpen the lines of the metal under investigation); and a dividing engine, whose screw was exceedingly accurate, used to measure the Zeeman separation.

Briefly the results of the investigation are as follows:

1. The separation of the outer components of the zinc lines 4680.38, 4722.26, 4810.71 is not proportional to the strength of field for values of the latter from 26,000 to 33,000 c. g. s. units; that is, Reese's results for zinc are confirmed and extended.

2. Further, for iron lines chosen somewhat at random the same is true, and the lines which, in the ordinary iron spectrum, are "nebulous" in character show the least increase in Zeeman separation as the field is increased in strength; or, in other words, the curve plotted between strength of field, "H," and resulting separation, "$\Delta\lambda$," shows the greatest droop.

3. Hence it follows that Becquerel and Deslandres,[1] who used a field of 35,000 c. g. s. units, were unjustified in their attempt to discover in the lines of the iron spectrum a law governing the separation. No such law as that proposed by them is apparent from measurements made on my plates of 80 lines which appeared in good form for measurement.

4. As to the pressure shift for iron:—In the spectrum of this metal 34 lines were investigated with great care. 26 show both large pressure shift and large separation, or small pressure shift and small separation; while 8 show either large pressure shift and small separation, or small pressure shift and large separation. Thus it cannot be said that, if a line show large pressure shift, it will show large separation; or, if small pressure shift, small separation.

5. Nickel and cobalt were investigated. No law governing the separation is apparent.

6. Preston's law that $\frac{\Delta\lambda}{\lambda^2 H}$ is constant for homologous lines of Kayser and Runge's spectroscopic series was extended. In the expression given, "$\Delta\lambda$" represents the Zeeman separation, "λ" the wave-length and "H" the field strength. Preston deduced this law from measurements upon the lines in the 2nd subordinate series of cadmium and magnesium, whose wave-lengths are given by putting "n" equal to 3 in Kayser and Runge's formula:—

$$\lambda^{-1} = A + Bn^{-2} + Cn^{-4}$$

where "λ" is the wave length, "A," "B" and "C" are constants and "n" has integer values 3, 4, 5, etc. The lines I have investigated are given in table No. 1. Table No. 2 contains in homologous positions the calculated values of $\frac{\Delta\lambda}{\lambda^2 H}$ as obtained from measurements made on my plates together with Reese's and Preston's results. Table No. 3 is obtained from table No. 2 by making corrections (fully justified[1]). Owing to the fact that, to obtain sufficient separation, it was necessary to use a field of over 26,000 c. g. s. units and that consequently, as the "droop" in the H-$\Delta\lambda$ curves before mentioned (see sections 1 and 2) is not the same for all lines, a comparison of $\frac{\Delta\lambda}{\lambda^2 H}$ is not possible until certain corrections have been made.

TABLE I.

LINES OF SPECTROSCOPIC SERIES INVESTIGATED.

	1ST SUBOR. SERIES.			2ND SUBOR. SERIES.					
	$n = 4$.			$n = 3$.			$n = 4$.		
Zn.	3252.42	3303.03	3345.62	4680.38	4722.26	4810.71			
Cd.	3103.74	3467.76	3613.04	4678.37	4800.00	5086.06			3252.63
Hg.				4046.78	4358.56	5460.97			
Mg.			3838.44	5167.55	5172.87	5783.84			
Ca.					6122.46	6162.16	4425.61	4435.86	4456.08
Sr.	4832.23	4876.35							

TABLE 2.(1) $\frac{\Delta\lambda}{\lambda^2 H} \times 10^5$.

METAL.	1ST SUBORDINATE.			2ND SUBORDINATE.											
	$n = 4$.			$n = 3$.									$n = 4$.		
				Kent's results.			*Reese's* (2).			*Preston's* (3)					
Zn.	5.1	8.5	11.4	16.5	14.9	8.9	17.0	15.3	11.3	17.	14.8	9.53			
Cd.	5.0	8.6	11.3	16.4	14.6	9.1	17.0	15.5	10.5						11.0
Hg.				16.7	14.7	8.7	16.7 (4)		10.3						
Mg.			11.1	16.1	14.1	9.0	16.7	14.9	10.5						
Ca.					[15.1	10.4]							4.8	8.2	11.4
Sr.	[12.8	12.5]													
Mean. (5)	5.1	8.6	11.3	16.4	14.6	8.8	16.9	15.2	10.7	17.	14.8	9.5	4.8	8.2	11.2

1. Field 26,460 c. g. s. units.

2. Reese's values calculated from slope of curve on H diagrams.

3. Approximate mean value given by Preston for the homologous lines of *Zn.*, *Cd.* and *Mg.* $H = 20,000$.

4. Calculated from data given by Reese. See his article before mentioned. *Astrophys. Journ.*, No. 2, Sept., 1900, p. 129.

5. Excluding strontium as it is irregular and calcium, the measurements of which are but approximate. Note that the calcium lines agree quite well with the homologous lines in *Zn.*, *Cd.*, *Hg.*, and *Mg.*

TABLE 3. $\frac{\Delta\lambda}{\lambda^2 H} \times 10^5$, corrected values.

1ST SUBORDINATE.			2ND SUBORDINATE.											
$n = 4$.			$n = 3$.									$n = 4$.		
			Kent's results.			*Reese's.*			*Preston's.*					
5.2	8.8	15.1	16.9	15.0	12.0	16.9	15.2	10.7	17.	14.8	11.1	4.8	8.4	14.9
Set 1	2	3	1	2	3	1	2	3	1	2	3	1	2	3

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[1] *Comptes Rendus*, No. 129, 1898, pgs. 18–24.

[1] The necessary corrections were determined by quite a complete study of the "droop" of homologous lines.

Table 3 shows:—

1st. That Preston's law: $\frac{\Delta\lambda}{\lambda^2 H}$ is a constant for homologous lines—established by him for the homologous lines of zinc, cadmium and magnesium given by $n = 3$ in the second subordinate series—appears to hold for the homologous lines in mercury and cadmium.

2nd. That, within the limits of accuracy of measurement, $\frac{\Delta\lambda}{\lambda^2 H}$ is the same for homologous lines given by $n = 4$ in both the subordinate series for zinc, cadmium, mercury, magnesium and calcium. This assumes that the lines not investigated show values of $\frac{\Delta\lambda}{\lambda^2 H}$, which are the same as those investigated in each set—an assumption which is certainly not unjustifiable.

3rd. That the average value of $\frac{\Delta\lambda}{\lambda^2 H}$—obtained from Preston's, Reese's, and my determinations—for the third set in $n = 3$, or $\frac{1}{3}$ $(12. + 10.7 + 11.1) = 11.27$, is so related to the average value for $n = 4$ (as given in the same table, No. 3) in the homologous sets of both subordinate series, or $\frac{1}{2}$ $(15.1 + 14.9) = 15.00$, that $\left(\frac{\Delta\lambda}{\lambda^2 H}\right)_{n = 3} : \left(\frac{\Delta\lambda}{\lambda^2 H}\right)_{n = 4} :: 3 : 4$; as $\frac{1}{3}$ $(11.27) = 3.76$, while $\frac{1}{4}$ $(15.00) = 3.75$. Thus, if we assume $\frac{\Delta\lambda}{\lambda^2 H}$ proportional to $\frac{e}{m}$ where "e" is the amount of electricity carried by the particle of mass "m," we may say that the ratio of the charge to the mass of the particle varies directly with "n" for the third set of lines in the second subordinate series where "n" has either the value 3 or 4.

(The first subordinate series shows no lines for $n = 3$. The value 15.1 was averaged with 14.9 because of the probability of obtaining thus a more correct mean).

4th. That there appears to be no relation between sets 1 and 2, $n = 4$, and 1 and 2, $n = 3$, or, taking total mean values, between

16.9, 15.0 for $n = 3$, and
5.0, 8.6 for $n = 4$.

However, inasmuch as the wave-lengths of the three lines forming the spectroscopic triplet are so related to each other that, given the wave-length of one of them, those of the other two can be calculated—thus forming a connection between the members of the triplet—we would not expect that here again a relation would appear between the first, second and third lines of the triplet in any one series unless, indeed, it were a relation equivalent to that just mentioned, namely, the possibility of the calculation of the wave-lengths of any two lines of the triplet given that of the third.

THE COLORS OF NOBILI'S RINGS.

By James T. Barrett.

In looking up what has been published on these rings it was found that wherever the colors are mentioned they are spoken of as "the colors of thin plates." No proof nor any reference to a proof of this appeared. To test this assumption a number of sets of the rings was made by electrolysis. A saturated solution of litharge in caustic potash was the electrolyte employed. The anode was a platinum point and the cathode a polished German silver plate. Two Leclanchè cells were found to give a suitable E. M. F. the anode being placed two or three mm. above the centre of the cathode. Metallic lead is deposited at the anode and lead dioxide on the cathode, the latter showing the brilliantly colored rings.

The fact that a regular succession of colors appears around a given point seems to indicate that it is a case of interference, the color varying with the thickness of the film of lead dioxide. Thus the cathode just under the point anode is at first yellow; this spreads out and blue appears inside it, then green and then red. The sequence is repeated until three or four sets of concentric rings of color are present on the plate. Under sodium light the rings are simply light and dark. There is one dark ring for each series of colors and it falls on what in white light is a blue ring. Therefore the colors may be due either to surface absorption or interference.

If it is a phenomenon of interference the transparency of the film must be established. In order to examine it a semi-transparent silver mirror was used as cathode. The rings could not be obtained on the mirror but the uniform yellow film which first appears on the German silver cathode was deposited. This was transparent. On examining the rings under a high-power microscope the instrument was brought to a focus where the German silver plate was seen in its original color, scratches, etc., leaving the rings out of focus, floating like colored clouds above the plate.

The fact that no shift of the colors can be observed on varying the angle of the incident light argues against interference. If, however, the film has a high index of refraction, a great change in the angle of incidence will make but little change in the path of the refracted rays. For in every case the ray will pass into the film almost perpendicularly. A slight shift may easily escape the eye. For such a case as this Wiener, in examining the colors appearing in certain photographs, used a prism to get a color shift (Smithsonian Reports for 1896).

This experiment was repeated on the Nobili's Rings. A right angle, 45°, glass prism was placed hypotenuse face down on the plate, the edge between the hypotenuse and one side face lying along the radius of the rings. The plate bearing the prism was then placed between the observer and the source of light so that the light fell almost normally on the face of the prism. Then at the edge of the prism nearest the eye, which cut the rings at a right angle, the colors could be viewed in air and under the glass. The rays in air and in the prism entered the film at different angles. By this means a color shift was obtained. For example the boundary between the red and green of one series was displaced under the prism about one millimeter with reference to its position in air. The shift was always toward the longer wave lengths. This shows that the colors are due to interference.

That the color shift can be observed with the prism but not without it is because by using the prism it is possible to compare directly the colors resulting from two different angles of incidence. Both series lie before the eye at the same time. On changing the angle of incidence without the prism by rocking the plate it is hard to locate accurately the boundary of two colors and it is difficult to examine the plate at large angles of incidence on account of blurring as though much light were scattered at the surface.

THE SPECTRUM OF HYDROGEN.

By Louis A. Parsons.

As early as 1865 Plücker and Hittorf made a study of the spectrum of hydrogen obtained by passing an electric discharge through a vacuum tube. The results of the large number of observers since that time have shown some marked anomalies in this spectrum; under varying conditions changes take place, but as to just what the determining conditions are and what are the underlying causes, there seems to be but little agreement. There are, as generally recognized, two distinct spectra of hydrogen—one the "four-line spectrum," consisting of some fifteen lines, four of which, Hα, Hβ, Hγ, Hδ, are in the visible portion of the spectrum, and the other, sometimes called the "compound spectrum," consisting of more than a hundred lines. Some of the earlier observers (as Ångström) considered the "four-line" as the true spectrum of hydrogen, believing the many-line spectrum to be due to impurities, but the latter is now generally recognized also as a true hydrogen spectrum. In fact Trowbridge, from some very interesting work with his high potential battery, has come to the conclusion that the many-line spectrum is the true one, while the four-line spectrum is due to the presence of water vapor.

As the pressure of the gas is increased there is in general a broadening of the lines, and further using the same resistance in the external circuit under certain conditions of pressure, there may be seen only the four-line spectrum, while under other conditions the many-line spectrum is seen, in which Hβ and Hγ appear as of only average intensity (while Hα may be absent). Some observers have believed these changes to be due primarily to variation of pressure. By increasing the pressure the lines were found to broaden out and to give at a few hundred millimeters a continuous spectrum. Schumann noticed that Hβ not only broadened but apparently split into two components which were unsymmetrically displaced. Others, including Wilsing, believe the effects to be due to temperature changes. He obtained fine lines at pressures almost up to an atmosphere, but at different pressures the lines were broadened (and there was a transition to the four-line spectrum) if a condenser was placed in the circuit, thus increasing, as he believed, the density of the discharge and consequently the temperature. Trowbridge was able to pass at will from the many-line to the four-line spectrum by putting in a condenser, and to reverse the change by the addition of self-induction or resistance, and concluded, in his earlier papers, that the determining factor is the character of the discharge, whether oscillatory or not. Wilsing believes, however, that since he got the same effect irrespective of the capacity of his condenser, that the effect could not be due to the oscillations, but to the increased temperature.

It was with a view to clearing up, or at least finding some facts which might prove useful in the statement of our notions of the hydrogen spectrum, that work on the subject was begun in this laboratory. Since the character of the discharge appeared to be an obviously important factor, a high potential storage battery was built, in order that a current as steady as possible might be obtained. The battery, which in the plan of construction resembles that of Professor Trowbridge, at Harvard, consists at present of 2000 cells giving a maximum voltage of nearly 4400. The discharge is sent directly through a vacuum tube (having a capillary of about 1 mm. diameter), having in series a water resistance of about 1½ megohms. The current is kept usually within the limits of from 1 to 5 milliamperes. On account of the low voltage (the spark length is a little less than 1 mm. in air) the battery cannot be used excepting at comparatively low pressures (under 12 mm. in the tube now in use), but we are at present making 2000 more cells, so that next fall we will have double our present voltage.

So far not many results have been obtained, but there are a few isolated facts which may prove of interest. For the production of the spectrum a Rowland concave grating of 57 cm. focus was employed, and photographs made on celluloid film bent to the required curvature, Hα ($\lambda = 6563$), was photographed on an Erythro plate. A plane grating and a camera were used for photographing the spectrum of the entire tube (without a slit). A Steinheil prism spectroscope was also used for some eye observations. With a tube of about 4 mm. internal diameter and electrodes of heavy aluminium wire about 1 cm. apart, using an induction coil without spark gap or condenser in the secondary circuit upon a faint background of apparently continuous spectrum, were seen Hα fairly sharp, and Hβ, Hγ, Hδ, all rather broad and hazy (the breadth increasing in the order named), and also quite a number of very fine lines. The color of the discharge was red, and was less than a millimeter wide, extending down the central part of the tube. The introduction of the spark gap and condenser greatly increased the diameter of the red discharge and also the intensity of the four lines relatively to the rest of the spectrum, and made them all broader and hazier. Hγ and Hδ appeared to be at least 50 Ångström units wide, while between them there were at least six very fine lines. At lower pressures, the red discharge appeared to be surrounded by a blue glow, which upon continuing the decrease of pressure (using the induction coil without the condenser) spread out until it finally filled the whole tube, the red discharge at the same time becoming fainter until nothing was left but the blue glow discharge. Simultaneously the four line spectrum grew fainter relatively to the continuous (?) spectrum, and at the same time narrower; Hα at start was of about normal width, afterwards Hβ became so; Hδ became invisible and Hγ became faint and narrow. Then with only the blue glow the four lines entirely disappeared excepting at the electrodes. The introduction of capacity at this point changed the discharge to red, and causing the four lines to appear bright. Similar changes were noticed with the tube with electrodes 10 cm. apart, excepting that the changes took place at a lower pressure. With the blue discharge a number of fine lines, of which Hβ was of average intensity, could be seen on a background of continuous spectrum in the blue-green. Upon decreasing the pressure more lines gradually appeared until at about 2½ mm. the spectrum was very brilliant, showing at least a hundred lines, of which Hα and Hβ were by far the brightest. The discharge was by this time a pinkish white, having changed gradually from the white. The introduction of capacity changed it to a salmon color and really decreased the intensity of the whole spectrum, but relatively increased that of Hα and Hβ.

The observations show that the intensity of the four lines is in some way intimately associated with the intensity of the red discharge, and further that the introduction of capacity always has a tendency to increase the red in the discharge, and under certain pressure conditions to change the blue discharge into the red. The conclusion of some observers that the effect of a condenser is to increase the current density and consequently the temperature does not seem to be justified. With a pressure of about 200 mm. a very brilliant red discharge was obtained with the induction coil and condenser, which gave the four line spectum of great intensity (no other lines were visible on the photographs), but although the discharge was continued for two hours steadily no serious heating of the tube occurred. Whenever the condenser was removed the discharge changed to blue, of relatively much less intensity, and the four line spectum disappeared, but in a comparatively short time the glass on the inside of the tube began to melt and a brilliant yellow glow appeared which gave the sodium line, but even then the four lines were not distinct, (although the Hα was seen). This shows that the temperature in the tube or near the walls of the tube without the condenser is much greater than with the condenser. Of course we cannot say anything definite as to the temperature along the center of the line of discharge. But it does not seem at all likely that the changes are due entirely to temperature. Nor has anything been observed which would go to show that the four line spectrum is due to water vapor boiled off the sides of the tube.

The battery gives essentially the same spectrum as the induction coil without the condenser. There appears to be a critical current strength at which a change takes place from a faint continuous spectrum with a number of fine lines (Hα invisible, Hβ very faint) to the characteristic spectrum with Hα and Hβ bright. This change was observed at two different pressures for a current of between 0.5 and 0.7 milliamperes. The work has only fairly started and will be continued throughout next year.

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—— An Application of the Method of Striae to the Illumination of Objects under a Microscope. (*Proc. Physical Society of London, Vol.* 17, *No.* 146, *p.* 358; *Phil. Mag., Vol.* 50, *No.* 304, *p.* 347, 1900.)

—— The Problem of the Daylight Observation of the Corona. (*Astrophysical Journal, Vol.* 12, *No.* 4, *p.* 281, *November*, 1900.)

—— Photography of Sound-waves and the Kinematographic Demonstration of the Evolutions of Reflected Wave-fronts. (*Phil. Mag., Vol.* 50, *No.* 302, *p.* 148, *July*, 1900.)

—— The Anomalous Dispersion of Carbon. (*Phil. Mag., Vol.* 1, *No.* 4, *p.* 405, *April*, 1901.)

—— The Optical Properties of Thin Carbon Films. (*Bull. Amer. Phys. Soc., Vol.* 1, *No.* 3, *p.* 57, 1900.)

Zahm, A. F. Resistance of Air at Speeds below One Thousand Feet a Second. (*Phil. Mag., Vol.* 1, *No.* 5, *p.* 530, *May*, 1901.)

—— A New Chronograph for Measuring Small intervals of Time. (*Bull. Amer. Phys. Soc., Vol.* 1, *No.* 4, *p.* 76, 1901.)

—— The Resistance of the Air determined at Speeds below One Thousand Feet a Second. With Description of Two New Methods of Measuring Projectile Velocities Inside and Outside the Gun. (*Washington*, 1900.)

—— Some Theorems in the Mechanics of High Speed Balloons. (*Washington*, 1900.)

Photographic Map of the Normal Solar Spectrum,

Made by Professor H. A. ROWLAND.

This series of photographs of the solar spectrum has been made in the Physical Laboratory of the Johns Hopkins University. Several concave gratings, of 6 inches diameter and 21½ feet radius, having 10,000 or 20,000 lines to the inch, were used for the purpose. The process of making this map is the well known Rowland method, and is based on the property of the concave grating as discovered by Professor Rowland: this property is that the spectrum, as photographed in any given order, is normal and of the same scale throughout. The negatives enlarged have been selected from many hundreds taken from different gratings, though three gratings were finally selected for the work. The negatives from any given order of spectrum are measured from one standard line to another on a dividing engine, so that the constant of the dividing engine is known. The scale is made by ruling on a piece of French plate glass having a coating of blackened collodio-chloride. The negatives are then clamped to the scale firmly, after being adjusted into position by the standards. They are next put in the enlarging apparatus; and the whole is enlarged from 2½ to possibly 4 times, so as to make the scale of the map about 3 times that of Angström's map. The positives thus made are then figured, and negatives are made from them by contact.

As to comparison with other maps of the spectrum made by measurement and drawing, it may be said that no comparison is possible. The photograph is the work of the sunlight itself, and the user of this map has the solar spectrum itself before him, and not a distorted drawing full of errors of wave-length and of intensity. The superiority is so great that there is no possibility for comparison.

The following is a list of the plates:

a	from wave length	3000 to 3330	f	from wave length	4850 to 5350
b	" " "	3270 to 3730	g	" " "	5250 to 5750
c	" " "	3670 to 4130	h	" " "	5650 to 6150
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Two plates have been made of the B and D lines. Two enlargements of some of the carbon bands from the arc electric light have also been made. They show the wonderful structure of these bands, each containing many hundred lines, each one of which is a close double or, in some cases, a triple.

These plates will be sold for $2.25 each, unmounted, or for $2.50 mounted on cloth.

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THE PHILIPPINE COMMISSION FOR THE STUDY OF TROPICAL DISEASES.

The following letter was not intended for publication, but it is of such general interest that the writer of it has consented to its appearance in this place.

Baltimore, *May 4th*, 1901.

Dear President Gilman:—

In compliance with my promise, I write to say that during the past few weeks we have had a striking illustration of the great value to the whole country of the Medical Commission sent out by the Johns Hopkins Medical School to the Philippine Islands. You may remember that this Commission consisted of Drs. Flexner and Barker and Messrs. Flint and Gay, of the Medical School. During the past year great uneasiness had existed in San Francisco, by reason of the certainty in the minds of medical men that bubonic plague prevailed among the Chinese in Chinatown. Owing to an unfortunate controversy between the Marine Hospital Service, representing the Government, and the local health officials, who were afraid to take efficient repressive measures, for fear that the commercial interests of the city might suffer, no steps were taken to prevent the spread of the disease, and there was every reason to fear that the plague had been introduced into the city, to the great peril of other sections of the country. In January last the condition became so alarming that the Treasury Department appointed Drs. Flexner and Barker, former members of the Philippine Commission, in connection with Dr. Novy, of the University of Michigan, Commissioners to visit California to ascertain the actual facts and to recommend efficient measures of relief. Upon reaching California they found a state of active antagonism between the State and Federal Governments upon the whole matter. The Governor, in fact, had gone so far as to have certain measures introduced into the Legislature which made it a penal offence to report cases of plague except under conditions which could not well be met by anyone. The Commissioners discovered that a disease resembling plague existed in Chinatown, and during the few weeks of their stay saw patients suffering from the disease, and from autopsies upon those who died, and careful cultures from the pathological material thus obtained, demonstrated beyond all doubt that plague existed in San Francisco. After they had demonstrated the existence of plague, they proceeded to formulate certain conclusions, which were extremely judicious, and which commended themselves to all who became familiar with them. With rare tact and good sense they also succeeded in disarming the prejudices of the Governor and bringing about coöperation between the State and Federal authorities. Through their efforts a large public morgue has been established in the city, to which all cases of persons dying from unknown or mysterious diseases are taken. They also arranged for the thorough inspection, examination and isolation of all suspected persons or persons who had come in contact with plague patients. From the familiarity with the disease which Dr. J. M. Flint, formerly of our Medical School, had acquired in Hong Kong and India, it was recommended that he take charge of the examination and isolation of plague cases. He has already entered upon his duties, and is conducting the work in a most efficient way.

There is a feeling upon the part of everyone that the situation in San Francisco, which threatened to be so serious, has now been fully met by a Commission made competent by experience gained at the Philippine Islands, and that San Francisco has been saved a very great pecuniary loss, and possibly the whole country has been spared an invasion of plague. These facts were brought out quite clearly in Washington this week at a meeting of the Association of American Physicians, where detailed reports were given of the operations of the Plague Commission in San Francisco.

Very truly yours,

Henry M. Hurd.

President Gilman,
Johns Hopkins University.

PROCEEDINGS OF SOCIETIES.

Scientific Association.

March 28, 1901.

- Recent Improvements in Professor Rowland's Printing Telegraph. By E. F. Northrup.
- The Magnetic Action of Electrical Convection. By H. Pender.

April 25.

- The Bureau of Weights and Measures of the U. S. By S. W. Stratton.
- Aluminium as a Source of Heat. By E. Renouf.

Philological Association.

April 19, 1901.—One hundred and ninetieth regular meeting. Professor Gildersleeve in the chair. Thirty-five members were present.

- The Literary Use of the Fable among the Greeks and the Romans. By H. T. Archibald.
- Mohammedan Traditions on the Book of Genesis. By G. Oussani.

May 17.—One hundred and ninety-first regular meeting. Professor Gildersleeve in the chair. Thirty-two members were present.

- Some Notes on Ancient Magic. By M. C. Sutphen.
- Intensive and Reflexive Pronouns in Old and Middle English. By J. M. Farr.

Historical and Political Science Association.

March 29, 1901.

- The United States Industrial Commission. By E. D. Durand.

Reviews:

- Robinson's The Philippines. By W. W. Brander.
- Stansbury's History of Criticism. By T. J. Stubbs.
- Davidson's Commercial Federation and Colonial Trade. By J. W. Harry.

April 12.

- Ordinance of Nullification and the Secession Movement. By J. H. Houston.

April 26.

- United States Navy Department. By C. O. Paullin.

Reviews:

- The Other Man's Country. By G. Cator.
- The Working Constitution of the U. S. By J. W. Harry.
- Up from Slavery, an Autobiography. By P. Hollis.

May 10.

- International Private Law in Japan. By Y. Hattori.

Reviews:

- Ruemlin's Politics and the Moral Law. By H. S. Hanna.
- Reinsch's French Experience with Representative Government in the West Indies. By J. W. Harry.
- Industrial and Railroad Consolidations. By G. Cator.
- The Present Crisis in Russia. The Russians in Manchuria, and Sir Robert Hart on China. By T. J. Stubbs.
- Education in the 19th Century. By O. P. McAuley.

May 24.

- Anti-Slavery Sentiment in Virginia. By J. C. Ballagh.
- History of Education in New York. By S. Sherwood.

Reviews:

- McCrady's South Carolina in the Revolution. By P. Hollis.
- Holt's Talks on Civics. By O. P. McAuley.
- Bingham's A Year in China. By T. J. Stubbs.
- Articles on China. By G. Cator.

STUDIES IN HONOR OF PROFESSOR GILDERSLEEVE.

A book entitled 'Studies in Honor of Basil Lanneau Gildersleeve' will be published in the autumn of 1901 to commemorate the seventieth birthday of Prof. B. L. Gildersleeve, of the Johns Hopkins University. It will consist of a number of philological articles contributed by his former students in the University of Virginia and the Johns Hopkins University.

Among the contributors to the volume will be

Prof. W. J. Alexander, University College, Toronto, Canada.
The Aim and Results of Plato's Theaetetus.
Dr. John W. Basore, Baltimore, Md.
The Value of the Illustrated Manuscripts of Terence.
Prof. Maurice Bloomfield, Johns Hopkins University, Md.
The Symbolic Gods.
Prof. George Melville Bolling, Catholic University of America, Washington, D. C.
The Participle in Apollonius Rhodius.
Prof. Charles A. Briggs, D. D., Union Theological Seminary, New York.
The Apostolic Commission.
Prof. Mitchell Carroll, Columbian University, Washington, D. C.
The Athens of Aristophanes.
Dr. Herman L. Ebeling, Trenton, N. J.
Some Statistics on the Order of Words in Greek.
Prof. George V. Edwards, Olivet College, Michigan.
Ingenio—Further Remarks on the Ablative of Quality.
Prof. H. C. Elmer, Cornell University, New York.
Ne emisses and ne poposcisses.
Prof. Edwin W. Fay, University of Texas, Texas.
An Unsolved Phonetic Law.
Prof. Edwin L. Green, South Carolina College, South Carolina.
μή for οὐ before Lucian.
Dr. Arthur Sewall Haggett, Worcester Academy, Mass.
The Uses of the Prepositions in Homer.
Prof. J. E. Harry, University of Cincinnati, Ohio.
Questions with μή and ἆρα μή.
Prof. G. L. Hendrickson, University of Chicago, Ill.
Horace and Lucilius (Horace Sat. 1, 10).
Dr. C. W. L. Johnson, Baltimore, Md.
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Prof. Christopher Johnston, Johns Hopkins University, Md.
The Fall of the Assyrian Empire.
Prof. Wm. Hamilton Kirk, Rutgers College, N. J.
Ad Catullum XXX, 4–5.
Dr. Gordon Jennings Laing, University of Chicago, Ill.
Notes on the Latin Verbs of Rating.
Prof. Emory B. Lease, College of the City of New York, N. Y.
The Use of atque and ac in Silver Latin.
Prof. James T. Lees, University of Nebraska, Nebr.
The Metaphor in Aeschylus.
Prof. C. W. E. Miller, Johns Hopkins University, Md.
The Laws of Greek Rhythm.
Prof. W. A. Montgomery, University of Mississippi, Miss.
Dio Chrysostomus, Orat. XI.—A Study in Sources.
Prof. A. T. Murray, Leland Stanford Jr. University, Cal.
An Interpretation of Euripides' Alcestis.
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Homeric Echoes in Matthew Arnold's Balder Dead.
Dr. Jens Anderson Ness, Baltimore, Md.
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Prof. Thomas R. Price, Columbia University, N. Y.
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Prof. Robert S. Radford, Bryn Mawr College, Penn.
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Prof. H. N. Sanders, McGill University, Montreal, Can.
Did Euripides write σκύμνων Hippol. 1276?
Prof. C. A. Savage, University of Minnesota, Minn.
The Athenian in his Relations to the State.
Prof. John A. Scott, Northwestern University, Ill.
A Tragic Fragment of Ion.
Prof. Ernest G. Sihler, New York University, N. Y.
Augustus Princeps.
Prof. Kirby Flower Smith, Johns Hopkins University, Md.
The Papula Duplex (Ovid, Am. 1, 8, 15).
Prof. Edward H. Spieker, Johns Hopkins University, Md.
The Pentapody in Greek Poetry.
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Chiasmus in the Letters of Seneca, Pliny and Fronto.
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Rime-Parallelism in Old High German Verse.
Dr. H. L. Wilson, Johns Hopkins University, Md.
The Use of the Simple for the Compound Verb in Persius.

Articles are also expected from Prof. Francis G. Allinson, of Brown University; Dr. J. W. Kern, of Baltimore; Prof. H. Rushton Fairclough, of Leland Stanford Jr. University; Prof. Gonzalez Lodge, of the Teachers' College, Columbia University; Prof A. W. Stratton, of the Oriental College of Lahore, India; Prof. B. L. Wiggins, of the University of the South; Prof. W. W. Baden, of the University of Idaho; and Prof. Alfred Emerson.

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